DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
WASHINGTON, D C 20363-5100

SPAWARINST 5100.9D
SPAWAR 00F
15 June 1992

SPAWARINST 5100.9D

From: Commander, Space and Naval Warfare Systems Command

Subj: NAVY SHORE ELECTRONICS SAFETY PRECAUTIONS

Ref: (a) OPNAVINST 5100.23B, NAVOSH PROGRAM MANUAL
(b) Code of Federal Regulations Title 29 Part 1910
(c) OPNAVINST 5100.19B
(d) OPNAVINST 3120.32B

Encl: (1) Navy Shore Electronics Safety Precautions

1. Purpose. To revise Navy shore electronic safety precautions in accordance with the safety requirements of references (a) and (b).

2. Cancellation. Enclosure (6) of SPAWARINST 5100.9C is cancelled. The remainder of SPAWARINST 5100.9C has been incorporated into SPAWARINST 4110.1 and SPAWARINST 5100.15.

3. Background. The Occupational Safety and Health Administration (OSHA) standards of reference (b) apply to all workplaces ashore. Enclosure (1) has been written to supplement these safety standards and the regulations in reference (a). Electronics Safety precautions afloat are addressed in reference (c).

4. Scope. This directive is applicable to Navy military and civilian personnel engaged in repair and maintenance of electronic equipment ashore. Additional information from references (c) and (d) is also provided for shore maintenance personnel who may in the course of their duties provide electronic maintenance services both ashore and aboard ship, especially in port. In case of conflict, any NAVSHIPS/NAVSEA or OPNAV regulations governing afloat safety will take precedence when aboard ship.

5. Responsibilities. SPAWAR 223-2/00F is designated as the SPAWAR office responsible for technical assistance regarding the safety precautions in enclosure (1). These precautions are a joint consensus of the Echelon 2 commands which have major shore electronics maintenance responsibilities and shall be referenced in all shore electronics maintenance requirement cards. Safety managers and supervisors at the activity level shall enforce the applicable principles of enclosure (1) as they pertain to the systems under their cognizance.

6. Reports and forms. No reports or forms are required by this instruction.

R. H. AILES
Rear Admiral, U.S. Navy

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NAVY SHORE ELECTRONICS SAFETY PRECAUTIONS

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NAVY SHORE ELECTRONICS SAFETY PRECAUTIONS

1.0 INTRODUCTION

The standards contained or incorporated by reference in this chapter provide general requirements for working safely with electronic equipment ashore (Paragraph 13 briefly addresses the documents for shipboard electronics safety). Manufacturer's operating or maintenance manuals contain equipment specific safety criteria. NAVFAC P-1060 provides safety precautions for work around electrical transmission and distribution equipment. The Occupational Safety and Health Administration (OSHA) electrical safety standards 29 CFR Subpart S and 1910.147 apply to most electrical and electronics installations and 29 CFR 1910.268 applies to telecommunications. 29 CFR 1926 Subpart K applies to construction sites. The following publications and standards are incorporated by reference.

1.1. NAVY/DOD PUBLICATIONS

a. NAVFAC DM-4, "Electrical Engineering."

b. NAVFAC MO-200, "Facilities Engineering Electrical Exterior Facilities."

c. SPAWAR 0101.110A, "Naval Shore Electronics Criteria; Installation Standards and Practices."

d. NAVSEA S9086-KC-STM-000/CH-300 R1, "Electrical Plant; General" (NSTM Chapter 300).

e. E0410-AA-HBK-010/00K ELEXSAFE, "Electronic Safety Handbook."

f. NAVFAC P-1060 "Electrical Transmission and Distribution Safety Manual."

g. NAVFACINST 5200.17 "Electrical Power Distribution System Maintenance, Live-line Bare-hand Work."

h. NAVSEA S6470-AA-SAF-010 "Gas Free Engineering Procedures."

i. NAVSEA S9310-AQ-SAF-010 "Batteries, Navy Lithium Safety Program Responsibilities and Procedures."

j. NAVSEA 0967-LP-000-0100 "Electronics Installation and Maintenance Book."

k. MIL-HANDBOOK 419 "Grounding, Bonding and Shielding for Electronic Equipment and Facilities."

l. DOD-HDBK-263 "Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment."

m. DOD-STD-1686A "Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment."

n. MIL-STD-454 "Standard General Requirements for Electronic Equipment."

o. MIL-T-28800 "Test Equipment for Use With Electrical and Electronic Equipment."

p. NAVSEA SO-420-AA-RAD-010, Radiological Affairs Program Support Manual.

1.2. OSHA PUBLICATIONS, Code of Federal Regulations, Title 29 (29 CFR)

a. 29 CFR 1910, Subpart S, "Electrical."

b. 29 CFR 1910.268, "Telecommunications."

c. 29 CFR 1910.147 "Lockout/Tagout".

d. 29 CFR 1910.178(g) "Changing and Charging Storage batteries."

e. 29 CFR 1915, Subpart L, "Electrical Machinery."

f. 29 CFR 1926, Subpart K, "Electrical."

g. 29 CFR 1926, Subpart V, "Power Transmission and Distribution."

h. 29 CFR 1910.331 -335, Electrical Safety Related Work Practices."

1.3. NATIONAL CONSENSUS STANDARDS (National Fire Protection Association (NFPA), American National Standards Institute (ANSI), American Society for Testing Materials (ASTM))

a. NFPA 70, "National Electrical Code" (NEC)."

b. NFPA 70E, "Electrical Safety Requirements for Employee Workplaces."

c. ANSI C2, "National Electrical Safety Code."

d. ASTM D 120, "Rubber Insulating Gloves."

2.0 GENERAL REQUIREMENTS

2.1. PERSONNEL REQUIREMENTS

2.1.1. Training and Competency. Only trained and competent personnel shall be permitted to work on electrical equipment and systems. All personnel who work on electrical or electronic equipment shall receive initial electrical safety training and annual update training per 29 CFR 1910.331 to 1910.335. Training shall also cover the requirements of the current issue of the National Electric Code as well as the other applicable publications in paragraphs 1.1 - 1.3. Personnel shall be fully informed of the hazards inherent in the maintenance of electrical and electronic equipment and shall receive proper instruction in accident prevention, cardio pulmonary resuscitation (CPR), approved first aid methods, rescue procedures, and fire extinguisher use.

2.1.2. Protection of the Public. All personnel shall know and understand warning signs and signals and shall warn others who are in danger near energized equipment or lines. Personnel shall promptly report to their supervisor any of the following conditions:

a. Line or equipment defects.

b. Accidentally energized objects, such as equipment case, conduits, light fixtures, guys, etc.

c. Other defects that may cause a dangerous condition.

2.2. PERSONAL PROTECTION

2.2.1. Clothing and Jewelry. The following requirements are for personal attire of employees while working on energized circuits.

2.2.1.1. Dry Clothing. Clothing, as well as hands, shall be dry. Personnel shall not wear loose clothing, such as ties or robes.

2.2.1.2. Metal Fasteners and Jewelry. Badges with metal chains, exposed metal zippers, buttons, buckles or other fasteners, and rings, wrist watches, bracelets, earrings, metal-framed eyewear or similar metal items shall not be worn while working on exposed live electrical equipment.

2.2.1.3. Shoes. Thin-soled footwear or footwear with exposed metal parts or hobnails shall not be worn. Nonconductive shoes meeting the requirements of ANSI Z41 shall be worn when working on live electrical circuits of 30 volts or more when deemed necessary by competent authority to protect personnel. The Navy standard stock electrical hazard safety shoe is designated for electrical and electronic repair work. See paragraph 2.2.2.6.2 for national stock number. Refer to MIL-S-43860 for specifications.

2.2.1.4. Head Protection. Head protection meeting the requirements of ANSI Z89.2 shall be provided when there is possibility of exposure to high voltage electrical contact. Head protection meeting ANSI Z89.1 shall be provided for other instances where only protection against impact or falling objects and limited low voltage electrical protection is required.

2.2.2. Special Protective Equipment and Procedures. The following paragraphs contain information about special equipment which may be needed or procedures which should be followed for personal safety. Additional items of personal protective equipment may be required by other OSHA and Navy regulations.

2.2.2.1. Safety Shorting Probe. Probes shall be rated for the voltage involved. Refer to NAVSEA Drawing RED 2697984. Paragraph 2.2.2.6.2 contains national stock numbers.

2.2.2.2. Rubber Insulation

2.2.2.2.1. Electricians' Rubber Gloves. Gloves shall be in compliance with ANSI/ASTM D 120 for use with voltages no greater than one of four classes: Class 0 (1,000 volts), Class 2 (17,000 volts), Class 3 (26,500 volts) and Class 4 (36,000 volts). If deemed necessary by competent authority to protect personnel working on live electrical equipment in excess of 30 volts, rubber insulating gloves shall be worn. Rubber insulating gloves shall not be used for any purpose except live electrical work. If the nature of the work requires that one hand be free of covering, it is permissible to do so, but a glove shall be worn on the other hand (See subparagraph 2.2.2.5. on metal tool handle design.). Glove use and maintenance requirements are as follows:

a. Ensure that complete detailed standard operating procedures are prepared and that they are correct and adequately address safety.

b. Before and after each use, gloves shall be checked by the user for punctures, tears, abrasions, embedded foreign objects, swelling, softening, hardening, or sticky or inelastic formations in the material. The gloves shall also be given an air test by rolling up the cuffs and forcing air into the fingers and palms of the gloves. If there is evidence of any leakage or thin spots, the gloves shall be replaced.

c. When rubber insulating gloves are worn, leather protectors shall always be worn over the gloves, except as follows:

(1) Protectors need not be used with class 0 gloves (rated for no more than 1,000 volts) when use of small equipment and parts necessitates unusually high finger dexterity.

(2) Any other class of glove may be used for similar work (as specified in (1) above) without protector gloves if the possibility of physical damage to the gloves is small and if the class of glove is one class higher than that required for the voltage involved.

d. Insulating gloves that have been used without protector gloves may not be used again until they have been tested in accordance with the applicable ASTM standards.

e. Rubber gloves or sleeves shall never be rolled down or worn inside out.

f. Under no circumstances shall two pairs of rubber gloves be worn at the same time.

g. Store gloves right side out. Do not store distorted. Do not store directly above or in proximity to steam pipes, radiators, or other sources of artificial heat, or expose to direct sunlight or other sources of ozone. Ambient storage temperature should not exceed 35 degrees C (95 degrees F).

h. Periodic testing shall be in compliance with the following table. This retesting shall be electrical, visual, and mechanical.

Gloves	Test Interval (months) Natural rubber	Synthetic rubber
New	12	18
Reissued	9	15

i. Periodic marking and storage of rubber gloves shall be performed in accordance with the applicable subsections of 29 CFR 1910.268(f).

j. Leather protectors shall not be used for any purpose other than with rubber gloves.

2.2.2.2.2. Rubber Matting. When servicing equipment or circuitry involving voltages greater than 30 volts, workers shall be insulated from accidental grounding by the use of approved insulating material on the floor. Rubber matting aboard ship shall be as specified in MIL-M-15562 (rated at 3,000 volts, 36 inches x 25 yards in size) except for Military Sealift Command (MSC) ships. Matting to be used at shore-based locations or on board MSC ships may also be in accordance with ANSI/ASTM D 178. Although the use of approved rubber matting is preferred, ashore dry wood or at least two layers of dry canvas, sheets of phenolic material, unapproved rubber mats or other equivalent insulating material may be used for voltages below 600 volts. The use of approved rubber matting is mandatory for voltages at or above 600 volts. Moisture, dust, metal chips, etc., shall be removed at once from insulating floor covers. See paragraph 2.2.2.6.2 for national stock numbers.

2.2.2.2.3. Rubber Insulating Equipment Standards. Rubber insulating equipment shall meet the requirements of the following standards:

a. ANSI/ASTM D 120, "Rubber Insulating Gloves."

b. ANSI/ASTM D 1048, "Rubber Insulating Blankets."

c. ANSI/ASTM D 1049, "Rubber Insulating Hoods."

d. ANSI/ASTM D 1050, "Rubber Insulating Line Hose."

e. ANSI/ASTM D 1051, "Rubber Insulating Sleeves."

f. MIL-M-15562, "Matting or Sheet, Floor Covering, Insulating for High Voltage Application."

g. ANSI/ASTM D 178, "Rubber Insulating Matting," as appropriate. (See paragraph 2.2.2.2.2.)

2.2.2.2.4. Rubber Insulating Equipment Test Standards. In addition to the user test for gloves required in 2.2.2.2.1, rubber insulating equipment shall be tested in accordance with the criteria and intervals of 29 CFR 1910.268 and the following standards:

a. ANSI/ASTM F478. "Specification for In-service Care of Insulating Line Hose and Covers."

b. ANSI/ASTM F479. "Specification for In-service Care of Insulating Blankets."

c. ANSI/ASTM F496. "Specification for In-Service Care of Insulating Gloves and Sleeves."

2.2.2.3. Climbing Equipment

2.2.2.3.1. Belts, Straps, and Lanyards. Lineman body belts, safety straps and lanyards shall be used as necessary by personnel working more than four feet above the ground on poles or towers, and as required by OPNAVINST 3120.32B and OPNAVINST 5100.19B for personnel going aloft. In addition to meeting the requirements of 29 CFR 1910.268, the equipment shall be capable of withstanding an AC dielectric test of not less than 25,000 volts per foot "dry" for three minutes without visible deterioration. Cushion parts of body belts shall have no exposed rivets on the inside. In addition, the use and test requirements of 29 CFR 1910.268(g) shall apply.

2.2.2.3.2. Pole Climbers. Pole climbers shall be inspected before each day's use. Fractured or cracked gaffs or leg irons, loose or dull gaffs, and broken straps or buckles shall be immediately corrected. Pole climbers shall not be used if the gaffs are less than 1-1/4 inches in length. They shall not be worn when working in trees, on ladders, or in aerial lifts. Pole climbers shall not be worn when walking on rocky, hard, or frozen ground, or when driving a vehicle.

2.2.2.3.3. Grounding of Metal Poles and Towers. Metal poles and towers shall be grounded in accordance with 29 CFR 1910.268(m).

2.2.2.4. Platforms and Ladders

a. Whenever it is necessary to work on electrical circuits or equipment in wet or damp locations, platforms made of non- conducting material shall be provided.

b. For all structures, OSHA standard 1910.24b requires installation of fixed stairs or ladder where operations require regular travel between levels. Fixed stairs and ladders shall be equipped with safety climbing devices per MIL-STD-1472 and OSHA standards 1910.268, 1910.24 and 1910.27. Two persons(one acting as safety observer) are required when electrical work is performed on ladders or platforms at least four feet above the ground or floor, whether or not the equipment is energized.

2.2.2.5. Metal Tool Handles. Only tools with insulated handles may be used on live electrical equipment. The shanks of screwdrivers used inside electrical equipment shall be insulated so that no more than 3/16 inch of the tip is exposed. Plastic handles are preferred; otherwise metal handles of hand-held tools shall be insulated by one of the following methods:

2.2.2.5.1. Taping Method. The handle and as much of the shaft as is practicable is covered with two layers of rubber or vinyl plastic tape half-lapped followed with a layer of friction tape half-lapped. Heat shrink tubing may also be used as one of the insulating materials.

2.2.2.5.2. Coating Method. Handle and shaft are dipped in a nonconductive plastisol solution.

2.2.2.5.3. Sleeve Method. In an emergency, where time does not permit using one of the previous methods, handles and shafts may be covered with a cambric sleeving, flexible plastic tubing, or insulating tubing removed from scraps of electrical cable.

2.2.2.6. Emergency Electronics Safety Boards. In high hazard areas and remote locations, as deemed necessary by the local safety manager and supervisor, emergency safety boards containing appropriate types of safety equipment and devices should be provided for the types of systems, equipment,

operations, locations, and number of personnel involved. (See Figure 2.2-1) If a 24 hour operational military or civilian infirmary, clinic or hospital (Emergency room or otherwise with an attending physician) is not more than 10 minutes away from the workplace a first aid kit is not required. In any case, the concurrence of the local dispensary is required for the use of first aid kits, including the standard kit listed below.

2.2.2.6.1. Contents. Emergency Electronics safety boards may contain the following items as appropriate to the operation:

a. Resuscitation and CPR instructions.

b. First Aid kits, fully stocked, sealed, and contents labeled on outside surface of kit.

c. A hook with a fiberglass handle or a fiberglass cane (pike pole).

d. Rope (15 feet by 1/2 inch hemp or polymer type composition).

e. Insulated rubber protective gloves that are certified annually.

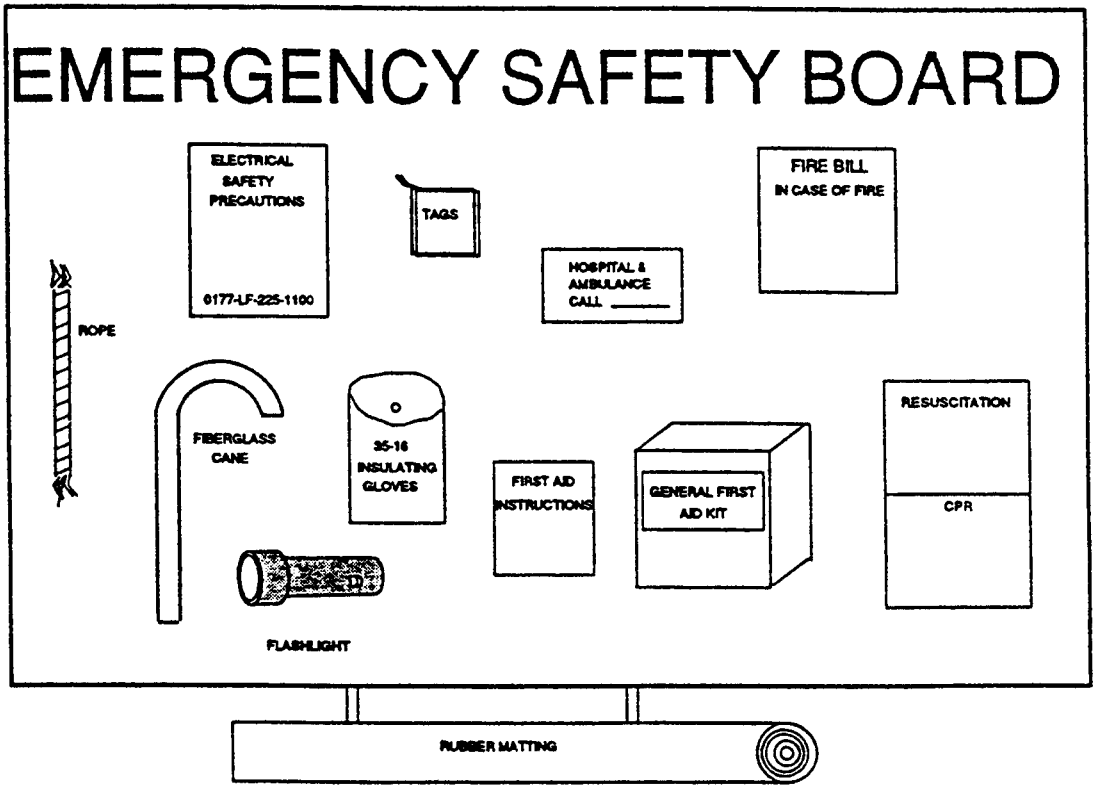


Figure 2.2-1. An Example of an Emergency Electronics/Electrical Safety Board

f. Flashlight (nonmetallic) marked with luminescent tape for easy location.

g. Wool blanket

h. Insulating rubber blanket or a 6 foot roll of rubber matting.

i. Shorting probes.

j. Any personal protective equipment that might be needed in the area in an emergency.

k. Emergency phone numbers.

l. Fire Bill.

m. Red danger tags and lockout devices.

n. Side cutting pliers with insulated handles (dikes).

2.2.2.6.2. Stock Numbers of Typical Electrical and Electronics Safety Items. Stock numbers, when available, of typical electrical and electronic safety items are as follows:

a. Placard, Safety precautions, electrical, 16 X 10 1/2 inches	0177-LF-225-1100
b. Placard, Safety precautions, electronic, 16 X 10 1/2 inches	0177-LF-211-8500
c. Placard, "Danger. No Smoking. Battery on Charge."	0177-LF-225-6800
d. Red DANGER tag for tagging out equipment	NAVSEA 0105-LF-641-6001
e. Electrical safety sign: DANGER HIGH VOLTAGE, 5" X 7"	1I-0177-LF-225-2100
f. Yellow "Read before operating" CAUTION tag	NAVSEA 0105-LF-641-3001

g. CPR instructions, 3 1/2 X 7 1/2 inch, wallet size (Posters may be available from the American Red Cross.)

h. First aid kit 9L-6545-00-919-6650
NAVSECGRU Authorized First Aid Kit.....9L6545-00-116-1410 with NSN 9L6505-00-926-2111 (meclizine hydrochloride sealed with contents listed next to kit.

i. Rope, 15 ft., hemp or polymer composition	9Z-4020-00-231-9005
(NAVSECGRU approved)	9G-4020-00-289-8616
j. Gloves, class 0, size 9, red label 1,000 volts	9D-8415-01-158-9453
k. Gloves, class 0, size 9 1/2, red label 1,000 volts	9D-8415-01-158-9454
l. Gloves, class 0, size 10, red label 1,000 volts	9D-8415-01-158-9455

m. Gloves, class 0, size 10 1/2, red label 1,000 volts	9D-8415-01-158-9456
n. Gloves, class 0, size 11, red label 1,000 volts	9D-8415-01-158-9457
o. Gloves, class 0, size 11 1/2, red label 1,000 volts	9D-8415-01-158-9458
p. Gloves, class 0, size 12, red label 1,000 volts	9D-8415-01-158-9459
q. Gloves, class 1, size 9, white label 7,500 volts	9D-8415-01-158-9449
r. Gloves, class 1, size 10, white label 7,500 volts	9D-8415-01-158-9450
s. Gloves, class 1, size 11, white label 7,500 volts	9D-8415-01-158-9451
t. Gloves, class 1, size 12, white label 7,500 volts	9D-8415-01-158-9452
u. Gloves, class 2, size 9, yellow label 17,000 volts	9D-8415-01-158-9446
v. Gloves, class 2, size 10, yellow lbl 17,000 volts	9D-8415-01-158-9447
w. Gloves, class 2, size 11, yellow label 17,000 volts	9D-8415-01-158-9448
x. Gloves, class 3, size 9, green label 26,500 volts	9D-8415-01-158-9445
y. Gloves, class 4, orange label 36,000 volts	(NSN unknown)
z. Gloves, leather shell worn over rubber gloves to protect against physical damage.	9T-8415-00-264-3618
aa. Rubber apron	9D-8415-00-082-6108
ab. Face shield	9Q-4240-00-542-2048
ac. Electrical hazard safety shoe, size 9N	8430-00-611-8744
ad. Electrical hazard safety shoe, size 10N	8430-00-611-8777
ae. Electrical hazard safety shoe, size 11N	8430-00-611-8786
af. Rubber mat, diamond tread, green (MIL-M-15562, Type 3)	9Q-7220-01-056-1944
ag. Rubber mat (MIL-M-15562, Type 2)	9Q-7220-00-913-8751

ah. Rubber mat, diamond tread, gray (MIL-M-15562, Type 3) 9Q-7220-01-057-1897

ai. Rubber mat (MIL-M-15562, Type 3) 9Q-7220-01-056-1944

aj. Rubber mat (MIL-M-15562, Type 2, tested to 30 kv, rated at 3 kv, 36 in X 4 yds., green) 9Q-7220-00-267-4630

ak. Woolen blanket 9D-7210-00-082-5668

al. Rubber insulation blanket (6' X 36", 20 kv) 9G-5970-00-296-5322

am. Flashlight, 1/2" dia., 4.4" length, plastic, incandescent, 3 vdc, watertight 9Q-6230-00-125-5528

am. Flashlight, 3" by .8" by 1.8" plastic, incandescent, water resistant, dust resistant 9Q-6230-00-164-7060

ao. Flashlight, 18" length, incandescent, adj. beam, aluminum, recharge. Ni-Cad batteries, weatherproof 9Q-6230-00-215-8559

ap. Flashlight (non-metallic).....9Q-6230-00-282-5418.
Luminescent tape to wrap on flashlight. 9390-00-282-7867

aq. Extension light (4 watts) 9G-6230-01-087-6125

ar. Extension light (8 watts) 1H-6230-00-244-3996

as. Shorting probe (25 kv) 9G-5975-01-029-4176

at. Shorting probe (7.5 kv) 9G-5975-00-146-1797

au. Test leads (Fluke) 9N-6625-01-05137

av. Test leads (Universal) 9N-6625-01-121-0510

aw. Tool tester (Biddle) 9N-6625-01-145-2789

ax. Megger (Biddle) 1H-6625-00-141-3558

ay. Plywood 9C-5530-00-129-7749

az. Fire bill 1H-0105-LF-001-6001

ba. Circuit breaker cover 9N-5925-00-360-3984

bb. Electrical switch stop 9N-5930-00-669-7524

bc. Electrical switch stop 9N-5930-00-669-7572

bd. Light, chemical wand (Box of 10) 9G-6260-01-074-4230

(The source of pike poles listed below is the GSA regional service office. All poles are straight and made of wood in two sections. Butt is 52.6 inches. Hook is 48.5 inches.)

bd. Pike pole, hook, 7 ft 9G-5120-00-116-6829

be. Pike pole, hook, 8 ft	9G-5120-00-243-2766
bf. Pike pole, no hook, 8 ft	9G-5120-00-223-8537
bg. Pike pole, no hook, 10 ft	9G-5120-00-223-8531
bh. Pike pole, no hook, 12 ft	9G-5120-00-293-1321
bi. Pike pole, no hook, 12 ft	9G-5120-00-596-1112
bj. Pike pole, no hook, 14 ft	9G-5120-00-223-8852
bk. Pike pole, hook, 16 ft	9G-5120-00-223-8541
bl. Light extension, 8 watts, nonconductive lamp	9G-5970-00-296-5322

(Blanket canister and glove bag protector are not in the system.)

2.2.2.7. Guards, Barriers and Other Safety Devices. The covers on fuse boxes and other types of wiring equipment and accessories shall be kept securely closed except when work is being done on them. The boxes shall be kept locked unless emergency access to the equipment is needed. If equipment must be left exposed and unattended, insulating or isolating barriers must be provided to prevent accidental contact; unauthorized personnel should be kept at least four feet away and warning signs posted to keep clear. Electrically insulating stools or platforms should be used to prevent contact between shoes and wet or damp floors. Safety devices such as interlocks, overload relays, and fuses should not be disconnected or altered except for replacement.

2.2.2.8. Alteration or Removal of Labels. Per 29 CFR 1910.303e markings, nameplates, cable tags or other identification shall not be mutilated, destroyed or removed.

2.2.2.9. Identification of Disconnecting Means and Circuits. All circuit breakers, switches, circuits, and other devices serving comparable functions shall be labeled to the extent specified in 29 CFR 1910.303(f).

2.2.2.10. Warning Signs. Danger or caution signs or tags shall be posted to alert personnel to actual or potential hazardous conditions involving electricity. Additional information on conventions used in preparing signs, labels, and tags can be found in 29 CFR 1910.144 and 145, ANSI Z53.1, and OPNAVINST 5100.19B.

2.2.2.11. Protection of Other Workers. When work is being performed within four feet of the exposed parts of electrical or electronic equipment by painters, carpenters, equipment operators, or other trades, an insulating barrier shall be erected or the circuits shall be de-energized. This procedure shall be employed whenever the voltage, rms or dc, is greater than 30 volts. The electronics worker or electrician in charge shall instruct other personnel working nearby of the hazards involved and shall provide and erect appropriate insulating barriers or de-energize and lock out the circuits.

2.2.2.12. Work Near Overhead Power Lines. Personnel(including the longest conductive object they may contact) and equipment, such as cranes, derricks, aerial lifts, ladders, scaffolds, etc., shall maintain a distance of at least 10 feet from energized unguarded overhead power lines rated at 50,000 volts or less. Minimum clearance for lines rated greater than 50,000 volts shall be 10 feet plus 4 inches for each 10,000 volts over 50,000 volts or twice the length

of the line insulator whichever is greater. Objects being used, which do not have an insulating rating for the voltage involved are also subject to these distance restrictions. Any overhead wire shall be considered energized until competent authority certifies that it is de-energized or visibly grounded.

2.2.2.13. First Aid Resuscitation. Before touching a victim of electric shock, the circuit shall be de-energized or the victim freed from the line conductor by the use of some suitable nonconductive object such as a dry wooden stick or safety hook. Cardiopulmonary resuscitation (CPR) procedures appropriate to the victim's condition shall be started immediately. A person who is qualified in CPR should be immediately available whenever work is being performed on live circuits. Qualification is obtained by periodic certification in the standard Red Cross or American Heart CPR Course.

2.2.3. Fire Safety

2.2.3.1. Fire Prevention. Gasoline, benzene, ether, and similar flammable fluids shall never be used on either energized or de-energized electrical apparatus. Alcohol shall not be used where a spark may occur from static electricity or for cleaning near electrical equipment from which a spark might be received. Machinery shall be kept absolutely clean and free of oil, grease, carbon dust, etc., to prevent ignition by electrical arcing. Warning signs shall be displayed where explosive vapors are present in any compartment or space. Electrical or electronic equipment shall not be energized within such areas while these signs are posted unless the equipment is rated explosion proof for the hazard per OSHA standards.

2.2.3.2. Fire Fighting Procedures. In the event of electrical fire, the following procedures shall be performed:

a. The circuits or equipment affected shall be immediately de-energized.

b. The fire department shall be notified.

c. When possible the fire shall be controlled through the use of approved fire fighting equipment until the fire department arrives.

d. In case of cable fires, the only positive method of preventing the fire from running the length of the cable is to cut the cable and to separate the two ends. The cable shall be de-energized before being cut.

2.2.3.3. Fire Fighting Equipment. Class C extinguishers shall be used to extinguish electrical fires. The stream from these extinguishers is nonconductive and can be directed against energized circuits without danger of shock.

2.3. WORKING ON ENERGIZED CIRCUITS. The OSHA electrical safety standards contained in Subpart S of 29 CFR 1910 apply to work on energized circuits. Most equipment has accompanying technical manuals issued by the Navy or provided by the manufacturer. The safety requirements of such manuals shall be followed. In the absence of such specific requirements, the regulations of this manual and of SPAWAR 0101.110A, "Naval Shore Electronics Criteria; Installation Standards and Practices," shall govern.

2.3.1. Verification of Nonenergized Circuits. All conductors and equipment shall be treated as energized until tested or otherwise determined to be de-energized or until grounded. Positive proof as to whether a conductor or a piece of equipment is de-energized must be established by the use of an approved voltage detector. Before being used, the detector must be checked on a conductor that is known to be energized and a positive indication noted.

This check on a known energized conductor must be repeated after the test on a de-energized conductor has been made. When it is not possible to recheck the voltage detector on an energized conductor, two voltage detectors shall be used, one as a check against the other.

2.3.2. Repair of Energized Circuits. Repairs are not to be made on energized circuits greater than 30 volts except in an emergency and then only with the permission of the commanding officer. A circuit must be considered energized until it has been checked and the switch opened, locked, and tagged. A qualified supervisor shall be in charge of testing for voltage and installing grounds. The presence of two technicians is required during work on energized circuits. The second technician will take station at the cut-off switch with a direct line of sight to the first technician doing repairs. Two technicians are also required when electrical work is performed on ladders at least four feet above the ground or floor, whether or not the equipment is energized.

2.3.3. Skill Requirements. Repair work on an energized circuit shall be performed only by personnel fully aware of the dangers involved. All work shall be supervised by qualified technicians or experienced communications or electronics material officers. Personnel should be stationed by circuit breakers or switches. Telephones should be manned so that circuits can be immediately de-energized in case of emergency. A person qualified to administer first aid and CPR for electric shock shall stand by during the entire period the work is being performed.

2.3.4. Precautions for Specific Voltages. Various safety practices have evolved during work within certain voltage ranges and are categorized below.

2.3.4.1. Voltages Less Than 600 Volts

Six hundred volts is generally considered by electricians to be the upper end of the lower voltage scale because roughly 600 volts has been found to be the skin puncture voltage. In other words, at higher voltages, the body is no longer protected by skin resistance, and is therefore subject to much higher, more lethal currents as a result of lower body resistance.

2.3.4.1.1. Special Design Safety Criteria. In electronics work, however, voltage levels much lower than 600 volts can be dangerous, and therefore their occurrence triggers the application of special design safety criteria. These criteria are contained in MIL-STD-454, Requirement 1, and are summarized as follows:

a. Thirty volts rms/dc or less - No special requirements unless working with high current in the range of several amperes or in an explosive atmosphere. For example, due to the high current/explosive gas capability of the standard 12 volt lead acid battery, provide barriers/add caution label to remove rings, other jewelry and metal chains on ID badges in order to avoid severe burns if the ring, chains, etc. could come in contact between the 12 volts and ground; wear face protection, provide ventilation and other cautions to prevent explosion.

b. Betweeen 30 and 70 volts rms/dc - Use special methods such as temporary barriers to protect from accidental contact.

c. Between 70 and 500 volts rms/dc - Guards and barriers, bypassable interlocks, shorting rods.

d. Measurements above 300 volts peak - Reduction of test points to 300 volts peak.

e. Greater than 500 volts rms/dc - Completely enclose and protect by non-bypassable interlocks.

2.4. LOCKOUT/TAGOUT

2.4.1. Introduction. A complete lockout/tagout program in accordance with 29 CFR 1910.147 and OPNAVINST 5100.23C shall be implemented. See Figure 2.4-1.

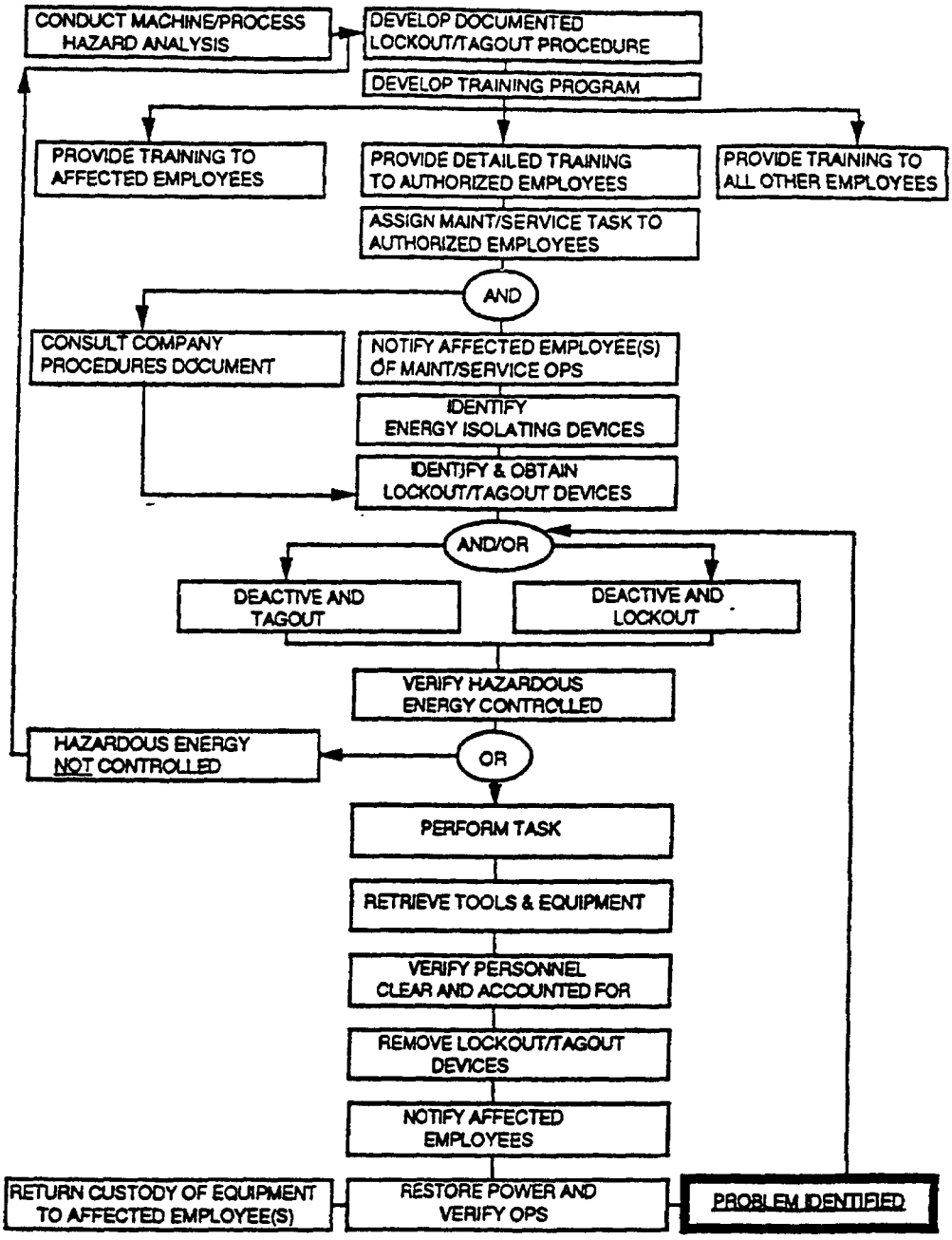


Figure 2.4-1. Flow Diagram for Typical Lockout Tagout Program

In summary, elements of the program are as follows:

a. Establish an equipment lockout/tagout control program.

b. Ensure that new or overhauled equipment can be locked.

c. Employ additional means (remove an isolating circuit element, block a controlling switch, open extra disconnect, remove valve handle, etc.) to ensure safety when tags alone rather than locks and tags are used. The decision to use tags alone must not be done without the approval of the supervisor.

d. Identify and implement specific procedures (generally in writing) for the control of hazardous energy including preparation for shutdown, equipment isolation, lockout/tagout application, release of stored energy, and verification of isolation.

e. Institute procedures for release of lockout/tagout including machine inspection, notification and safe positioning of employees, and removal of the lockout/tagout device,

f. Obtain standardized locks and tags which indicate the identity of the employee using them, and which are of sufficient quality and durability to ensure their effectiveness.

g. Conduct inspections of equipment lockout/tagout control procedures at least annually.

h. Train employees in the specific equipment lockout/tagout control procedures and provide retraining when changes occur.

i. Adopt procedures to ensure safety when equipment must be tested during servicing; when outside contractors are working at the site; when a multiple lockout is needed for a crew servicing equipment; and when shifts or personnel change.

2.4.2. Protective Materials and Hardware

a. Management Issue. Locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware shall be provided by management for isolating, securing, or blocking of machines or equipment from energy sources. Typical lockout and tagout devices are shown in 2.4-2 and 2.4-3.

b. Properties. Lockout devices and tagout devices shall be singularly identified; shall be the only device(s) used for controlling energy; shall not be used for other purposes; and shall meet the following requirements:

(1) Durability.

(a) Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.

(b) Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.

(c) Tags shall not deteriorate when used in corrosive environments such as areas where acid and alkali chemicals are handled and

stored.

(2) Standardization. Lockout and tagout devices shall be standardized within the facility in at least one of the following criteria: color, shape, or size; and additionally, in the case of tagout devices, print and format shall be standardized.

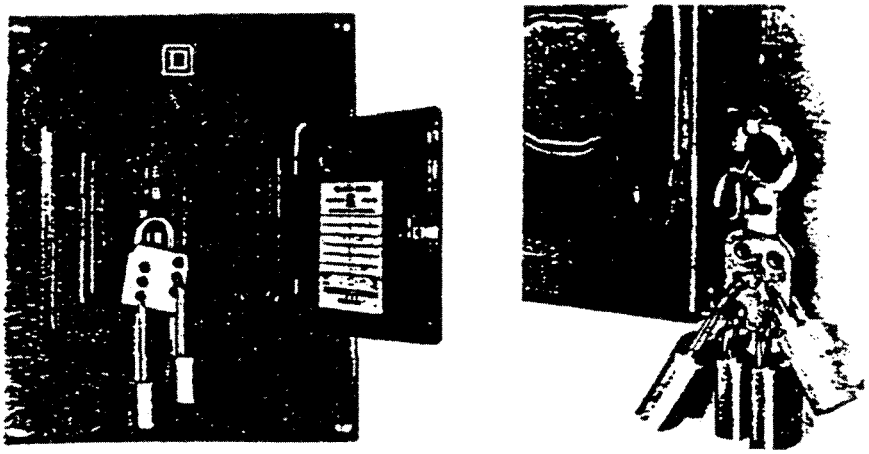
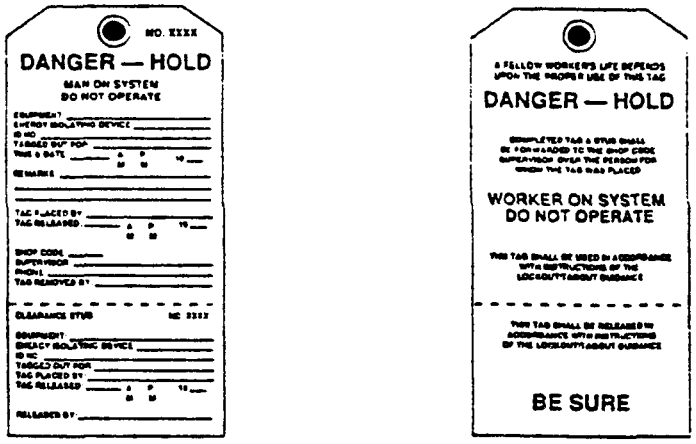


Figure 2.4-2. Typical Lockout Devices.



EXAMPLE OF TAGOUT (REDTAG)

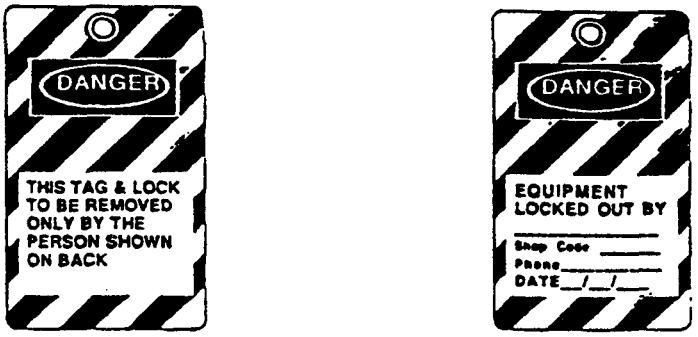


Figure 2.4-3. TAGS TO ACCOMPANY LOCKOUT DEVICE

(3) Strength

(a) Lockout Devices. Lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters or other metal cutting tools.

(b) Tagout Devices. Tagout devices, including their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be of a non-reusable type, attachable by hand, self-locking, and non-releasable with a minimum unlocking strength of no less than 50 pounds, and having the general design and basic characteristics of being at least equivalent to a one-piece, all-environment-tolerant nylon cable tie.

(4) Identification. Lockout devices and tagout devices shall indicate the identity of the employee applying the device(s).

c. Tag Information. Tags shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: "Do Not Start, Do Not Open, Do Not Close, Do Not Energize, Do Not Operate." The hazard warning tag shall be affixed to the switch by the person directly in charge of repairs. When more than one repair party is working, a tag shall be placed on the switch for each party and only that party may remove it. A typical tag is shown in figure 2.4-3.

2.5. CONFINED SPACES. Dead spaces such as voids, tanks, seldom used storerooms, cable trunks, manholes, and other areas lacking adequate ventilation shall be certified safe by a gas free engineer from the local public works/activity safety office prior to entry. See OPNAVINST 5100.19B, OPNAVINST 5100.23 Series and the NAVSEA Gas Free Engineering Manual, NAVSEA S6470-AA-SAF-010.

2.6. INSPECTIONS. Electrical and electronic appliances and equipment shall be periodically inspected for adequacy and functioning of safety features and for damaged insulation and loose connections. The exact periods of time should be determined by the safety manager or other qualified person. Appliances and equipment found to be defective shall be removed from service.

2.7. GROUNDING

2.7.1. Fault Protection Subsystem (Green Wire Grounding Conductor) Description. The fault protection subsystem provides a low impedance electrical connection to the earth ground point of the ac power system for the protection of personnel in the event that a malfunction causes the metal frame of a tool/equipment to become accidentally energized. A ground bus or conductor shall interconnect (bond) all noncurrent-carrying metal equipment, chassis, equipment cabinets and racks, all ferrous shields and covers, all conduits, raceways, cellular flooring, cable racks and superstructures, and the protective ground of local telephone systems. The integrity of the protective grounding system is assured by running an unbroken, insulated, green wire along with the ac power conductors that supply the equipment. The wire, which is connected between the equipment case and the power panel, is designated the green wire fault protection subsystem. This green protective grounding wire is required to be run with the power conductors even though the power conductors are supported in metallic conduit or other supports. The green protective grounding wire shall not be smaller than the largest of the current carrying (power) conductors.

NOTE: The green grounding wire does not replace the color-coded white or

natural gray wire used for the neutral grounded return side of all shore ac power feeders. The green grounding wire and white neutral return grounded wire are both connected to the ground buss at the service entrance panel.

The protective green grounding wire and the signal ground must be maintained separately and insulated from each other up to common connection at a single earth electrode. All grounding busses shall be as short and straight as possible and shall not contain closed loops, sharp turns or twists; all bends shall have a minimum radius of 4 inches and a maximum angular change of 90 degrees at any one point. The ground electrode or earth connection point should be as near the main signal distribution frame as possible to minimize the length of ground busses and ground connectors. The ground electrode should also be in an accessible location for inspection and maintenance purposes. Impedance between any equipment enclosure and the ground electrode when measured with a ground impedance tester should be less than 0.5 ohms.

2.7.2. Grounding Assurance. Installers and users are responsible for ensuring that noncurrent-carrying metal parts are grounded (except UL listed double insulated equipment). The resistance between the metal bases and frames of electrical equipment and ground should be checked at regular intervals, especially after repairs, to ensure that an effective ground has been maintained, i.e., an impedance less than 0.5 ohms.

2.7.3. Grounding of Noncurrent-Carrying Metal Parts. Any noncurrent-carrying metal parts, such as metal pipes, partitions, grill work, and enclosures, near equipment of more than 750 volts between conductors shall be grounded. This includes grounding fences around transmitting antennas. Any large metal parts or equipment within 6 feet of a lightning down conductor shall be grounded.

2.7.4. Bonding Requirements. The National Electrical Code requires that separate systems be bonded together to reduce their differences of potential which can result from lightning or electrical power.contacts. Interconnection of grounds at the earth grounding point is required for lightning protection systems, power ground system and communication/electronic systems signal ground. Bonding conductors shall be connected by a good mechanical and electrical attachment that will make a permanent effective bond. Connection devices of fittings that depend on solder alone shall not be used. Nonconductive coatings (such as paint, lacquer, and enamel) shall be removed from all equipment surfaces or metal threads that are to be used as bonding attachment points.

2.7.5. Grounding Requirements During Servicing. The chassis and frame of all power supplies and high voltage units (operating above 30 volts) removed for servicing shall be grounded prior to applying power to the unit. Personnel must remember that the removal of a unit or part from the normal location within an assembly and the energizing of the unit or part while it is outside the normal enclosure removes the protection given by built-in protective features such as interlocks, grounds, and enclosures. Since these safety features then no longer exist, special precautions and safety measures must be taken. Whenever a unit is removed from its enclosure, it shall be grounded by means of a safety ground strap prior to applying power.

2.7.6. Raised Access Floors. An electric shock hazard may result from delamination between the high pressure plastic laminate (HPL) and the grounded steel panels of raised access floors commonly used as flooring in computer equipment rooms. The most frequent cause of delamination of HPL from its metal base is use of excessive water and soap during cleaning of the floors. Therefore the following guidelines should be observed for proper cleaning and maintenance of HPL raised floors.

a. Daily Maintenance

1. Vacuum the floor.

2. Clean the floor with a damp mop, thoroughly wringing out the mop beforehand to make it as dry as possible. Use no soap or additives. Do not scrub the floor.

3. Remove any remaining substances with cleaner sparsely applied to a cloth used for localized rubbing. Remove all cleaner residue from the floor surface.

b. Weekly Maintenance

1. Buff traffic areas lightly.

c. Semiannual Maintenance

1. Remove the raised floor panels and thoroughly vacuum the space below the floor. Take proper precautions so that wiring, boxes, etc., are not damaged.

2. Scrape and clean any dirt buildup under the raised floor panels and support system.

2.8. PORTABLE POWER TOOLS

2.8.1. GFCI Requirements. Hand-held electric power tools that are not double insulated shall be issued and used only with an Underwriters Laboratories (UL) listed ground fault circuit interrupter (GFCI) in wet or damp locations and at construction sites.

2.8.2. Assured Equipment Grounding Conductor Program. Anyone providing or using a temporary (portable) cord set, receptacle, and cord- and plug-connected equipment rated for or used in a 15 or 20 ampere, 120 volt, single phase system shall be in compliance with the following requirements, as specified by 29 CFR 1910.304(b)(ii):

a. All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

b. Each receptacle and attachment plug shall be tested for correct attachment of the equipment grounding conductor to ensure that the equipment grounding conductor is connected to its proper terminal.

c. All required tests shall be performed: before first use; before equipment is returned to service following any repairs; before equipment is used after any incident which can be reasonably suspected to have caused damage (e.g., when a cord is run over); and at intervals not to exceed three months.

d. All required tests shall be recorded. The test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval during which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained by the workplace supervisor until replaced by a more current record.

2.8.3. Portable Power Tool Safe Practices

a. If a tool has a guard, do not use it without the guard.

b. Do not use in the vicinity of flammable gases or vapors.

c. Do not hang cords over nails or sharp edges, or string cords along surfaces where they may be damaged by vehicles, persons, or materials passing over them.

d. Avoid placing cords in such a way that they become a tripping hazard.

e. Do not carry or suspend tools by the cord.

f. Do not operate while wearing long neckties, loose clothing, large rings, or other items which might get caught in moving parts.

g. In compliance with 29 CFR 1910.133, wear goggles or safety glasses when using a portable grinder, buffer, sander, or any other device which may cause dust, grit, or chips to fly. Use respirators and face masks approved by the respiratory protection manager as necessary to safeguard against the inhaling of contaminants produced by these operations.

h. Disconnect cord before changing accessories.

i. Avoid excessive oiling to prevent deterioration of the cord and insulation.

j. Do not clean with flammable or toxic solvents. If pressurized air is employed, use only air pressure less than 30 psi and wear eye protection.

k. Store away from possible damage and dampness with the cord coiled so that it will not be abused.

3.0 ELECTRICAL REQUIREMENTS

The standards listed in paragraph 3.1 through 3.6 are incorporated by reference. These are general electrical standards. Additional detailed standards may be found in NFPA 70, "National Electrical Code," which is also incorporated by reference.

3.1. GENERAL. Requirements for marking equipment, splicing, disconnect means, guarding live parts, enclosures, and work spaces are contained in 29 CFR 1910.303, "General Requirements."

3.2. WIRING DESIGN AND PROTECTION. Standards for grounding, clearances, and overcurrent protection are described in 29 CFR 1910.304, "Wiring Design and Protection."

3.3. WIRING METHODS, COMPONENTS, AND GENERAL USE EQUIPMENT. Requirements for wiring cabinets, switches, flexible cord, and general equipment are covered in 29 CFR 1910.305, "Wiring Methods, Components, and General Use Equipment."

3.4. SPECIFIC PURPOSE EQUIPMENT AND INSTALLATIONS. Requirements for some specific equipment such as data processing systems, are in 29 CFR 1910.306, "Specific Purpose Equipment and Installation." The Underwriters' Laboratories (UL) and the American National Standards Institute (ANSI) together have developed detailed safety standards for over 100 separate items of electric equipment. These standards should be consulted for safety requirements information not addressed by OSHA standards.

3.5. ELECTRICITY IN HAZARDOUS LOCATIONS. Requirements for electrical equipment and wiring used in locations classified as hazardous because of the presence or potential presence of flammable or explosive concentration of gases, vapors, dusts and fibers, are listed in 29 CFR 1910.307, "Hazardous Locations." The determination of whether or not a location is hazardous shall be made by the activity safety office based on the criteria in the National Electric Code and in 29 CFR 1910, Subpart H.

3.6. SPECIAL SYSTEMS. Requirements for systems over 600 volts, emergency power systems, signaling systems, and communication systems are found in 29 CFR 1910.308, "Special Systems."

4.0 OPERATING AND MAINTENANCE PRECAUTIONS

4.1. HAZARDS IN OPERATING AND MAINTAINING ELECTRONIC EQUIPMENT INCLUDE:

a. Electric Shock. Voltages as low as 30 volts may be fatal, depending upon the path of the current, whether it passes through the heart, the amount of current, and the length of time the current is flowing. 60 Hz ac current is most dangerous.

b. Fire. Electronic equipment fires generally occur from electrical short circuits, overheated motors, and use of flammable liquids in the presence of an electric spark or hot surface as well as paper in contact with an overheated surface.

c. Radiation. Hazardous levels of radio frequency (RF) radiation and microwaves, lasers, infrared, visible and ultraviolet light, X rays from high voltage tubes and radioactive tubes as well as noise from high speed mechanisms may be present.

d. Hazardous Materials. The use of beryllium oxide ceramics, mercury, waveguide pressurizing gases, cleaning agents such as trichloroethane and freon, and other potentially hazardous materials all require special precautions.

4.2. GENERAL PRINCIPLES

a. Assume all conductors are live until tested. Do not use bare fingers to test for live circuits. When testing circuits, use the appropriate procedures given in the following sections.

b. Use temporary or permanent insulation over exposed voltages to prevent both accidental shocks to personnel and damaging shorts in equipment. No person should reach within or enter an energized electronic equipment enclosure except when prescribed by official technical manuals, and then only in the immediate presence of another person capable of administering emergency aid. Any cleaning of live equipment must be done with nonmetallic implements (and with a nonflammable cleaning solution).

c. Before closing any power switch, ensure that the equipment is ready and not being worked on. All circuit breakers should be operative, and fuses properly placed. Replacement fuses must be the same value as marked on the equipment.

d. The principle of good housekeeping, "A place for everything, and everything in its place," shall be followed. Areas around electronic equipment and power panels shall be kept clear. Overcurrent device boxes and panels shall be kept securely closed unless work is being done on them. Tools not in use shall be returned to their designated storage spaces. Make it a habit to keep circuits covered. No loose objects are allowed above any electrical equipment that must be left open. No person shall take loose metal parts, tools, or liquids near or above a starter box or above open electric or electronic equipment. No person shall be permitted above any open electronic apparatus with loose metal objects attached to clothing. Storage or insertion of tools or other foreign articles in or near switchgear, control appliances, panels, etc., is strictly forbidden.

e. Do not alter, disconnect, bypass, or modify safety devices on electronic equipment such as interlocks, overload relays, and fuses without authorization of the cognizant equipment design authority.

f. Protect cables from mechanical damage.

g. Post danger signs where appropriate to warn personnel of hazards involved in servicing or using electronic equipment.

4.3. PREPARATORY SAFETY PRACTICES

a. The deck underneath and surrounding electronic equipment or workbenches where measurements, service and maintenance are performed on exposed energized parts, shall be covered with electrically insulating material complying with section 2.

b. Personal protective equipment such as electrically insulating shoes, electrically insulating gloves, eye and face protection, aprons, etc. shall be worn as appropriate.

c. Smoking shall not be allowed in electronic maintenance areas.

d. Electrical outlets and workbench wiring should be checked at least quarterly by trained personnel to assure proper wiring and grounding and detect deteriorated wiring.

e. Workbench structure shall be inspected periodically (periodicity determined by mutual agreement of the safety manager and workplace supervisor) to ensure that working conditions or bench configurations have not changed to introduce any hazard.

4.4. SERVICING, ADJUSTING, AND MEASURING

4.4.1. Procedures Prior to Servicing, Adjusting, and Measuring

a. Because of the danger of fire, damage to material, and injury to personnel, all repair and maintenance work on electronic equipment shall be done only by duly authorized and qualified personnel.

b. Areas open to personnel traffic shall be excluded by barriers whenever possible.

c. Study equipment schematics and technical manuals before starting work. Plan ahead, decide what to do and which tools are needed before beginning work.

d. Before performing corrective or routine maintenance on any electronic equipment, the main supply switches or cutout switches in each circuit from which power can be supplied shall be secured in the open or "safety" position and tagged. When more than one party is checking a circuit, a tag for each party shall be placed on the supply switch. Each party shall remove only its own tag upon completion of the work. Locking devices can be obtained through normal supply.

e. Have ample lighting available.

f. Make only authorized equipment modifications. Immediately upon completion, log all modifications in appropriate records.

g. Safeguard against shocks from capacitors and pulse forming networks.

h. Never work on energized electronic equipment by yourself. Have another person (safety observer) qualified in CPR and first aid for electrical shock present at all times. The safety observer should also know which circuits and switches control the equipment, and should be given instructions to pull the

switch immediately if anything unforeseen happens.

i. Use one hand for switching or working on circuits whenever possible. Keep free hand clear.

j. Use protective safety grounds. Ground all metal enclosures. De-energize and ground antennas at the antenna coupler when working on them. Prior to beginning, locate the ground nearest the repair work. If there is none, then tag and use a remote ground. Check the resistance between the metal bases and frames of electronic equipment and ground at regular intervals, especially after repairs to ensure that an effective ground has been maintained.

k. Use cables of proper length and cross section. If possible, don't splice.

l. Replace frayed wiring or wire that is wrapped in dried out insulation.

m. Do not use metal ladders for electrical work.

n. Beware of exposed metal set screws and shafts, they may be hot. Knobs and phone plugs with set screws should have the screws covered with electrical insulation.

o. Use isolation transformers when servicing equipment without input power transformers and when using tools or lamps (preferably of low voltage) in wet locations.

p. Replace all insulation over terminals.

q. Contact with the insulation on wires carrying RF current shall be avoided. This insulation can act as the dielectric of a condenser when touched, causing shock or burn injury to personnel.

r. Be cautious of energized 130 vdc 60 ma phone plug when removing it from telephone patch panel.

s. Do not place any loose metal parts, tools, or liquids near or above electric or electronic equipment. No person with loose metal objects attached to his/her clothing shall be permitted above open electric or electronics apparatus. Stowage or insertion of tools or other foreign articles in or near switchgear, control appliances, panels, etc., is strictly forbidden.

4.4.1.1. Shorting Devices. Extreme caution shall be taken prior to working on or near de-energized circuits which employ large capacitors or pulse-forming networks. An approved grounding or shorting bar or probe shall be used to short circuit all terminals and contacts to ground. This precaution shall be taken regardless of the length of time the equipment has been de-energized. Some pulse-forming networks are capable of retaining their charges several hours after the equipment is secured and all power disconnected. Shorting probes are designed to be used with the braid-end connected to equipment ground. Never attempt to connect the shorting probe directly across a capacitor before the capacitor has been discharged.

After determining that the equipment ground connection to earth is good, connect the braid-end of the shorting probe to the equipment ground terminal. The equipment ground terminal is used instead of earth ground to insure least discharge path resistance. While holding the probe by its insulated handle, touch the probe end to each capacitor terminal. Even though a capacitor terminal arcs when touched, leave the probe end in contact with the terminal for several seconds. The reason for this is that the discharge of a capacitor takes the form

of an exponential decay curve, approaching zero at decreasing time rates based on the product of the resistance and capacitance in the discharge path. A good rule is to leave the probe in contact with each terminal for at least 15 seconds. It is good practice to leave the probe in place while working on the equipment.

4.4.1.2. Interlocks and Safety Devices. Safety devices on electronic equipment such as interlocks, overload relays, and fuses, shall not be altered, disconnected, or modified without specific authority from the commanding officer.

4.4.2. General Guidelines for all Voltage Measurements

a. Carefully study entire circuit schematics and wiring diagrams.

Note all circuits that must be de-energized including the main power supply. Ensure that test equipment is rated for the voltage to be measured.

b. Notify and obtain permission from your supervisor and the maintenance supervisor in charge before working on energized equipment.

c. If approval is given to work on equipment with power applied, never work alone.

Have an assistant fully CPR qualified to administer aid for electrical shock.

The assistant must be familiar with the most rapid and efficient means of removing power from the equipment under test.

Always wear electrical protective footwear or stand on approved rubber matting.

d. Use only test equipment approved for the type of measurements being made.

Use test probes with safety guards or barriers on the probe body that will prevent the hand from inadvertently contacting the probe tip.

Use insulation over exposed metal on alligator clips.

Whenever possible, do not use unprotected banana plugs which may inadvertently be pulled out of the measuring devices leaving a voltage on the base of the banana plug.

e. When making measurements or testing, keep your body clear of any metal. Remove all jewelry and badges on metal chains.

When practical, keep one hand behind your back or in your pocket.

Stand on an insulating surface such as an approved rubber mat.

f. Do not reach into the equipment enclosure unless

absolutely necessary. When this must be done, make sure that approved insulating materials and procedures are used.

Stand on rubber matting, wear rubber gloves, etc.

g. Contact with high voltage insulation or wires carrying high voltage shall be avoided.

High voltage insulation can act as the dielectric of a condenser when contacted, causing shock or burn injury to personnel.

h. Intentionally taking a shock at any voltage is always dangerous and is strictly forbidden.

Whenever it becomes necessary to check a circuit to see if it is live, a test lamp, voltmeter, or other appropriate indicating device shall be used, and then only by a qualified technician.

i. As a minimum, ensure the following safety equipment is available for use. (See paragraph 2.2.2.6.2. for stock numbers.)

Safety Shorting Probe: Rated at 25,000 volts.

Electrician Rubber Gloves: Rated at 6,000 volts.

Rubber Matting: Rated at 3,000 volts, meeting MIL-M-15562.

Electrical Hazard Foot Wear: Electrical hazard shoe, rated at 600 volts.

4.4.3. Working on Energized Circuits. Repairs are not to be made on energized circuits except in an emergency. A circuit must be considered energized until it has been checked and the switch opened, tagged, and locked. A qualified supervisor shall be in charge of testing for voltage and installing grounds.

4.4.3.1. Precautions. Work on energized equipment shall be avoided whenever possible. Personnel should not reach within or enter prescribed equipment enclosures except when servicing or adjusting is prescribed by official applicable technical manuals, and then only with the immediate assistance of another person capable of rendering adequate aid in the event of an emergency. Insulating barriers must be provided to prevent accidental contact with circuits when work is done in the area of exposed electrical circuits. Personnel shall be warned to exercise extreme caution when reaching into the enclosures of equipment having internal exposed high voltage points. The metal shielding shell of some capacitors, klystrons, cathode-ray tubes, and other components may be at high potentials above ground.

4.4.3.2. Qualifications. Repair work on an energized circuit shall be performed only by personnel fully aware of the dangers involved. All work shall be supervised by qualified technicians or experienced communications or

electronic material officers. Personnel should be stationed by circuit breakers or switches. Telephones should be manned so that circuits can be immediately de-energized in case of emergency. A person qualified to administer first aid and cardiopulmonary resuscitation (CPR) for electrical shock shall standby during the entire period the work is being performed.

4.4.3.3. Clearance. A minimum body clearance from energized lines and equipment shall be maintained by personnel working on or around electrical equipment of high voltage, as given previously. For specific clearances, refer to 29 CFR 1910.303(g)(1)(i) if the voltage is 600 volts nominal or less. If the voltage is greater, comply with 29 CFR 1910.303(h)(3)(i).

4.4.3.4. Test Probes. Do not hold test probes for measurement in excess of 300 volts. De-energize equipment and discharge capacitors. Secure test leads to test points, withdraw, energize equipment and observe the readings. Before removing test leads, de-energize equipment and discharge capacitors.

4.4.4. Voltage Measurements in Excess of 300 Volts. Many serious accidents, some resulting in fatalities, have occurred while taking voltage and differential voltage measurements. The following guidelines are intended to reiterate safe practices for making voltage measurements including those in excess of 300 volts. Such high voltage measurements leave no margin for error since even the slightest oversight may result in severe injury or death.

Before making voltage measurements greater than 300 volts, the following must be considered:

a. Do not make voltage measurements unless directed to do so by the technical manual for the equipment under test.

b. Employ a "two-worker" policy.

c. Before starting work, familiarize yourself with the test procedures in the technical manual. Know in advance the voltage levels and locations of the test points. (This familiarization does not preclude the use of the technical manual during the test).

d. Select and make sure the test equipment to be used is capable of measuring expected voltages. For example, if a voltage probe is to be used, make sure the probe reduces voltage to a useful level that is not hazardous to the user or measurement device. It is especially important for ungrounded references, such as shipboard power systems, that the probe common input to the measurement device be isolated from the case ground of the test equipment.

e. Voltage probes used with voltage measurement devices vary with respect to the maximum voltage they will tolerate. Consult the instruction data sheet accompanying the probe for operational characteristics and for the proper method of

securing it to the test circuit. For example, one voltage probe carries the warning: "To avoid electrical shock make sure the probe ground lead is securely connected to signal common (ground)." Of particular importance is the fact that the ground lead is not capable of handling the voltage that would result in the test circuit if the leads were reversed to change polarity on the meter. The voltage could then arc back through the meter to the probe handle.

Note: Voltage probes for television applications present a shock hazard if used for measurements on equipment other than TV. They are for positive measurements only and are restricted to TV use. Voltage probes must have safety guards or barriers on the probe body to prevent the operator's hand from inadvertently contacting the probe tip.

4.4.4.1. Voltage Probes. Some acceptable voltage probes and their limitations are as follows: (Keep in mind that, though some voltage probes may be used with a wide range of measurement devices, when applied to differential voltage measurements in ungrounded power systems such as shipboard power system measurements, the device to which the probe is attached must be capable of isolating the case ground and the chassis ground.)

a. Tektronix P6015: 40 kv peak pulse, 20 kv dc or rms continuous; used for oscilloscope applications.

b. Fluke 80K-40: 40 kv dc or peak ac, 28 kv rms ac, used for digital multimeter application.

c. Fluke 80K-6 (89536): 5 kv; this probe is found only with the Fluke Digital Multimeter which carries the designation 8000A/BU+HVP.

d. AN/USM-381: dc differential voltmeter capable of high voltage measurements; 0 to 110 vdc; range is extended to 15,000 vdc with a separate input.

4.4.4.2. Procedures for Measuring Voltages greater than 300 Volts. The following guidelines are presented in the sequence in which they are to be applied:

a. De-energize the equipment to be tested.

b. When necessary to assure safety, attach appropriate warning tags and install lockouts.

c. Before connecting the measurement device, discharge capacitors using an approved shorting probe.

d. Attach ground clip of measuring device first.

e. Secure measurement probe to the test point.

f. Make sure controls of measurement device are in proper configuration for the voltage level and polarity being measured.

g. Stand on rubber mat back from equipment under test but in a position to read the measurement device. (Do not touch measuring device).

h. Energize the equipment under test and make the measurement.

i. De-energize the equipment under test.

j. Discharge high voltage capacitors.

k. Remove the test leads.

4.4.5. Differential Voltage Measurements

4.4.5.1. Precautions. When performing voltage measurements between two voltage points, neither of which is at ground potential, observe the following:

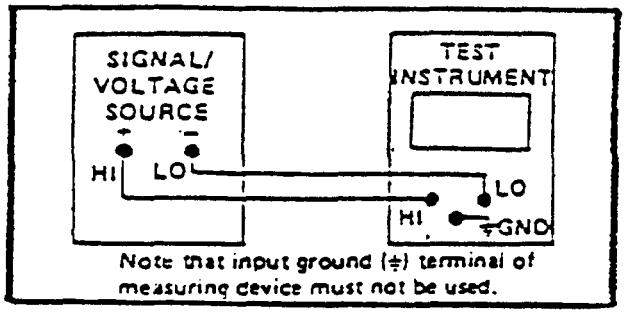
a. Use only measuring devices specifically designed and approved for the test being performed.

b. Ensure that both test leads of the test instrument are isolated from ground.

c. Do not use an isolation transformer or other means to float any measuring device which has a grounded common input. This would cause a potentially lethal voltage to exist on the case of the test instrument.

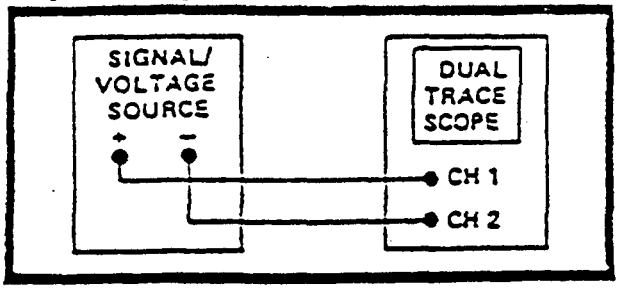
d. When using test equipment with positive (+), negative (-) and ground (⊥) input terminals, remove the shorting bar between the negative and ground terminals.

e. Ensure that the case of the measuring device is always connected to earth safety ground or ship's hull.



4.4.5.2. An Alternate Measurement Method. A differential voltage measurement can also be made using any standard dual trace oscilloscope. Using this method, the channel 1 probe is connected to the positive (+) side of the signal, and the channel 2 probe to the negative (−) side. With channel 2 inverted and the A + B mode selected, the oscilloscope displays the difference signal.

Care must be taken that the probes used are capable of withstanding the level of the voltage with respect to ground.



4.4.5.3. Differential Voltage Measurement Oscilloscopes. The following oscilloscopes, under SCAT Code 4311, are acceptable for measurements involving differential voltage measurements (e.g., shipboard power systems). They may be used for high voltage applications when an appropriate probe is utilized.

a. Hewlett-Packard 1200A-C16, NSN 6625-01-068-6694

b. Hewlett-Packard 130C, NSN 6625-00-069-5477

Note: on models equipped with positive (+), negative (−), and ground (⊥) input terminals, the Hewlett-Packard 130C, for example, the shorting bar between the negative terminal and the ground must be disconnected for differential voltage measurements).

c. Tektronix 212, NSN 6625-00-061-5510

d. Tektronix 213

e. Tektronix 5110

f. AN/USM-368

4.5. Static Electricity

For a thorough treatment of this subject, consult DOD-HDBK-263 and MIL-STD-1686A. The following is a summary of basic information.

4.5.1. Background

Static electricity is the electric charge generated and stored on certain low conducting substances as a result of rubbing or moving those substances across other dissimilar materials which readily yield electrons. As an example, more than 40,000 volts can be generated on a person's body after walking with rubber soled shoes across a high pile nylon rug in low humidity weather. During maintenance of electronic equipment, static electricity discharge of voltages as low as 100 volts can inadvertently be discharged through vulnerable semiconductors to ground, destroying the thin oxide layers on the semiconductors which serve as insulators between metallic contacts. Another risk associated with static electricity is the tendency to jump back or jerk away from a shock in the presence of unguarded, moving machinery or while on a ladder. A third

hazard is the generation of a static spark in spaces containing chemically active gases or vapors, or combustible dusts or particles.

4.5.2. Electrostatic Discharge (ESD) Controls

The way to control hazards caused by ESD is to provide a path by which separated charges may recombine harmlessly. Three common ways of doing this are (1) bonding and grounding, (2) ionization of the surrounding media, and (3) humidification. Ionization (the ionizing of air in immediate contact with a charged body to create a conductive path through which the static electricity can be discharged to ground) and humidification (increasing the moisture content of air to increase the surface conductivity of materials so that static accumulations leak off to ground more rapidly) are not typical DOD workplace methods and will not be discussed further.

4.5.3. Bonding and Grounding

When two conducting bodies are electrically connected with a conducting wire, they are said to be bonded. As long as they are bonded, they will be at the same electrostatic potential and sparks will not jump between the two. Bonded objects, however, may have a different potential from other objects and from ground. To prevent this, it is necessary to ground the bonded objects. Bonding and grounding and other methods of ESD control can be accomplished by the following actions:

CAUTION: Energized electronic equipment shall not be serviced at ESD protected workstations.

a. Use cables and resistors which have ample current carrying capacity. Since the purpose of a work station ground is to bleed off electrostatic charges, a one half watt resistor is usually sufficient.

b. Provide ground cable connections which are continuous and permanent.

c. Ensure that resistances to ground are high enough, considering all parallel paths, to limit leakage current for personnel safety to five milliamperes maximum, based upon the highest voltage source accessible by grounded personnel. Such voltage sources include power sources and test equipment.

d. Select a ground cable and connection material of sufficient mechanical strength to minimize the possibility of inadvertent ground disconnections.

e. Connect current limiting resistances (see MIL-W-87893) in series with work station tops, floor mats, ground straps, and other ESD-protected area grounds used to discharge static electricity to earth, the power system ground or other hard grounds, as appropriate. ESD grounding systems for workbenches should not be connected in series with one another because the series resistances are additive and would therefore result in higher ESD dissipation times. Also, opening of one ground cable could affect the opening of other workbench ground cables.

f. Electrically connect carriers, holders, or containers together before transferring ESD sensitive parts from one to the other.

g. Use special personnel grounding devices and clothing as necessary to minimize the possibility of sparking, such as conductive shoes, clothes made with metal fibers, and wrist straps grounded by connection to a grounding wire. CAUTION: Personnel wearing any grounding devices such a wrist straps, conductive clothing or conductive shoes shall not service energized equipment.

h. Check insulated handles of hand tools for static generation and periodically treat with an antistatic application.

i. Short together the terminals of electrostatic discharge sensitive (ESDS) equipment items using metal shunting bars, metal clips, or noncorrosive conductive foams. When the equipment has metal cases, the shunt should also contact the case. To act effectively, the resistance of the shunting material should be orders of magnitude below the minimum impedance between any two pins of an ESDS part.

j. When humidity can be controlled, set the relative humidity between 40 and 60 percent as long as it does not result in accelerating rust formation or other detrimental effects such as printed circuit board (PCB) delamination during soldering.

4.6. SOLDERING IRONS. When using a soldering iron, always remember the following:

a. Ensure that the resistance from the tip of a hot soldering iron to ground is less than 5 ohms so that the voltage buildup will be less than 2 millivolts rms. Three wire cords with tip grounding are recommended. Soldering guns of the transformer type are not recommended. (See MIL-STD-2000A).

b. To avoid burns, always assume that a plugged-in soldering iron is hot.

c. Never rest a heated iron anywhere but on a metal surface or rack provided for this purpose. Faulty action on your part could result in fire, extensive equipment damage, or serious injuries. (Most metals have a high thermal conductivity, so if there are flammable materials in contact with the metal, they too may heat, and then ignite).

d. Never use an excessive amount of solder. Hot drippings may cause serious skin or eye burns or short circuits.

e. Do not swing an iron to remove excess solder. Bits of hot solder that are removed in this manner can cause serious skin or eye burns, or bits of hot solder may ignite combustible material in the work area.

f. When cleaning an iron, use a cleaning cloth but DO NOT hold the cleaning cloth in your hand. Always place the cloth on a suitable surface and wipe the iron across it to prevent burning your hand.

g. Hold small soldering jobs with pliers or a suitable clamping device to avoid burns. Never hold the work in your hand.

h. Do not use an iron that has a frayed cord or plug.

i. Do not solder electronic equipment unless the equipment is electrically disconnected from the power supply circuit.

j. When soldering, always wear protective eyewear to prevent injury from the spattering hot solder.

k. Do not solder/weld cadmium or materials containing cadmium or use solders containing cadmium without an air supplied respirator and in spaces where other personnel can be exposed. Cadmium fumes may be lethal. Use cadmium-free substitutes wherever possible. For all other soldering ensure adequate ventilation is in accordance with industrial hygienist recommendations.

l. Smoking or eating shall not be allowed while soldering.

m. After completing the task requiring the use of a soldering iron, disconnect its power cord from the receptacle and, when the iron is cooled off, stow it in its assigned storage area, or for electronic soldering irons with a built-in power switch turn off the power switch.

4.7. WORKBENCHES FOR ENERGIZED ELECTRONIC EQUIPMENT

The following requirements are all-inclusive. Application of these requirements to specific work situations requires discretion and good safety judgment. Final resolution of the most practical safe workbench installation shall be accomplished as a joint effort between the safety manager and workplace supervisor.

4.7.1. General Types of Workbenches

Figure 4 shows the preferred wooden electronics workbench for use ashore. Figure 4A shows a standard insulated metal electrical/electronics workbench originally designed for shipboard use. Other sources of design requirements for electronics workbenches are the following: NAVAIR Drawing 63-A-114 series; General Specifications for Naval Ships NAVSEA 59AA0-AA-SPN-010/GENSPEC articles 331b, 320c, 634, and 665f; MIL-STD-1310 series (Navy); General Safety Design Criteria for Ships of the United States Navy, 9677-AA-SAF-000/GEN-SAF-DES-CRIT; and NAEU Drawing 6SE00063. NAVAIR Drawing 63-A-114J1 specifies workbench assembly components as follows (Item "e" is cited from "Stowage Guide for Portable Electrical/Electronic Test Equipment (PEETE)," NAVSEA ST000-AB-GYD-010/PEETE.):

a. Cabinet assembly 1R-6625-00-851-2156

b. Base assembly 1R-6625-00-851-2157

c. Back plate & shelf assy. 1R-6625-00-851-2158

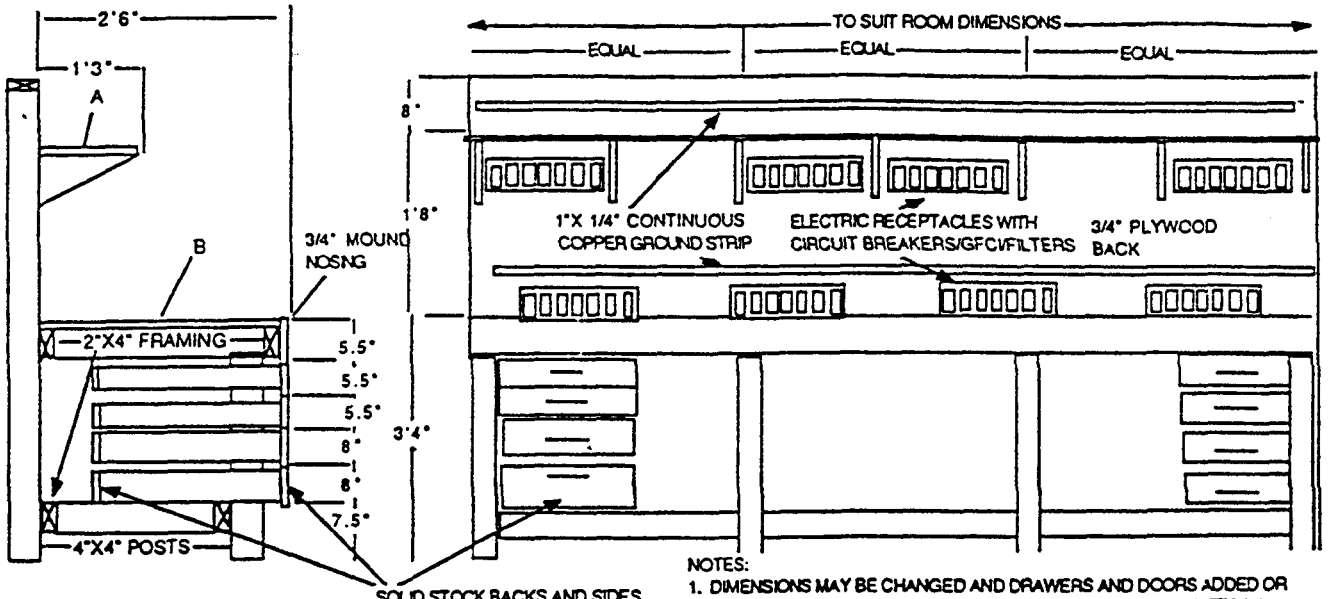
d. Auxiliary table assy. 1R-6625-00-851-2159

e. Terminal board 1R-6625-00-851-8026

The surface of metal workbenches shall be insulated as follows:

(1) The top working surface, front of drawers and surface of doors shall be an insulating material with a minimum of 3/8 inch material equivalent to the insulating requirements of MIL-I-24330 (SHIPS) "Insulation Sheets, Electrical, Ligno-Celluosic, High Density, Hardboard," (Benelex #401). Insulation over metal should be installed as a single piece and shall be secured to the working surface with countersunk plastic machine screws (NSN 5305-01-004-4983).

(2) Workbench sides, kneeholes, exposed metal wall surfaces within three feet of the workbench, and all other uninsulated surfaces which a person might touch while performing normal maintenance at the workbench shall be insulated. Use 1/8 inch plastic electrical insulation laminate conforming to MIL-P-15037 (NSN 9Q 5970-00-912-1908) to insulate these surfaces. Attach the laminate to the surfaces using 1/4-20 plastic screws, or cement conforming to Federal Specification MMM-A-130.



A. SHELF IS 3/4" PLYWOOD WITH 1.5" X1/4" METAL SUPPORT BRACKETS 2'-3' ON CENTER

B. BENCH TOP IS PLASTIC LAMINATE OVER 1/4" PLYWOOD COVERING A 602 COPPER PAN WITH 3/4" PLYWOOD BOTTOM.

NOTES:

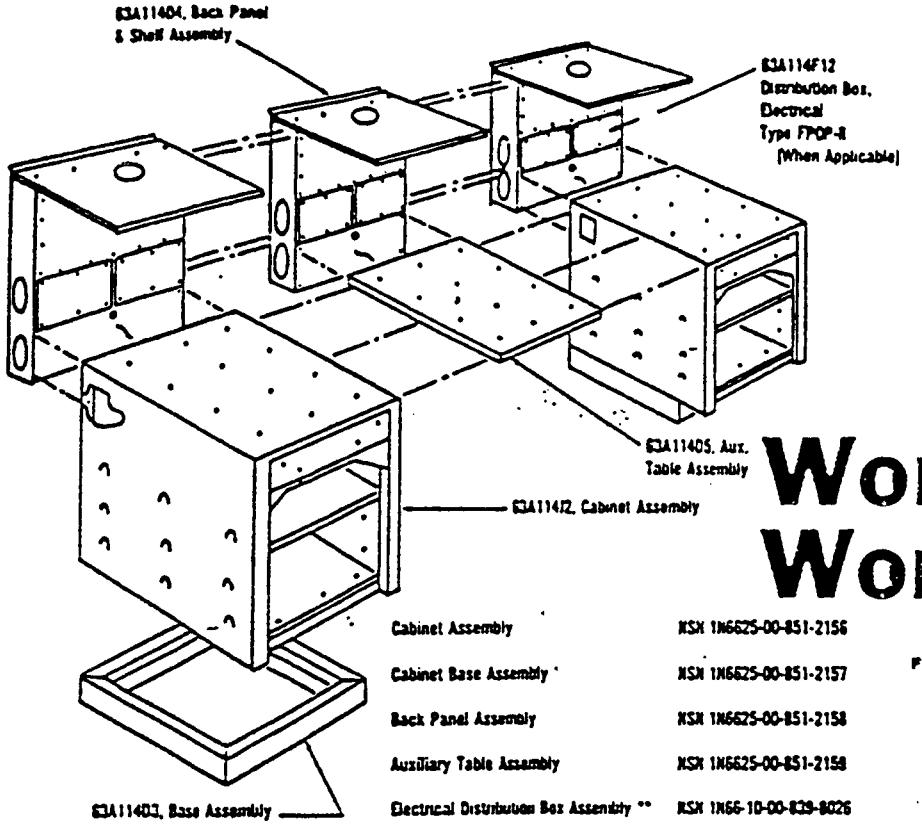
1. DIMENSIONS MAY BE CHANGED AND DRAWERS AND DOORS ADDED OR VARIED TO SUIT THE LOCAL REQUIREMENTS. SIZES FOR SOLID STOCK MILLWORK ARE EXAMPLES AND NOT INTENDED TO BE ALL INCLUSIVE. EXACT DETAILS FOR LUMBER MAY VARY ACCORDING TO LOCAL PRACTICE.

2. EXPOSED SURFACES SHALL BE COVERED WITH ONE COAT OF LACQUER SEALER, ONE COAT MEDIUM COLOR SHADING STAIN AND TWO COATS OF SEMI-FLAT LACQUER FINISH.

3. LAMINATED PLASTIC TOP SHALL CONFORM TO MIL-T-17171 CIGARETTE BURN RESISTANT, NOT LESS THAN 1/16"THICK. CORE MATERIAL SHALL BE 3/4" THICK EXTERIOR GRADE AC, ROTARY CUT, CLOSE GRAIN PLYWOOD.

4. THE COPPER PAN BENEATH THE BENCH TOP AND COPPER GROUND STRIPS SHALL BE GROUNDED DIRECTLY TO THE BUILDING GROUNDING SYSTEM.

Figure 4. Typical Wooden Electronics Workbench



Workbench Worries

Cabinet Assembly	NSN 1N6625-00-851-2156
Cabinet Base Assembly *	NSN 1N6625-00-851-2157
Back Panel Assembly	NSN 1N6625-00-851-2158
Auxiliary Table Assembly	NSN 1N6625-00-851-2159
Electrical Distribution Box Assembly **	NSN 1N66-10-00-829-8026

FATHOM diagram by Frank L. Smith

* Not part of old design and optional for use with new cabinet assembly. Provides 4" elevation and toe space. Required for shore base installations only.

** Optional with shipboard installations.

Figure 1

ONE of the more common discrepancies cited by Board of Inspection and Survey (INSURV) reports and encountered by members of the Naval Safety Center's Submarine Safety Survey teams are improperly constructed or installed electronic/electrical workbenches. There's a great deal of confusion in this area among shipboard, shipyard and tender personnel. General purpose workbenches are being mistaken for electronic/electrical workbenches; electronic/electrical benches are being incorrectly constructed and installed aboard submarines, and electronic/electrical workbenches are being improperly modified by both Intermediate Maintenance Activities and ships.

At first glance the general purpose workbench and the electronic/electrical workbench may appear to be the same. Closer inspection reveals significant differences. When inspecting the workbench in your work center to determine if it's an electronic/electrical workbench, look for the following:

- The top, front of drawers and surface of all doors should be insulated with 3/8-inch Benelex 401 insulating material (NSN 9Q 5640-00-256-5194).
- All other exposed metal surfaces (including knee hole side panels) should be insulated with 1/8-inch Benelex 401 (NSN 9Q 5640-00-256-5195).
- Hinges and drawer pulls should be made of nylon.
- Grounding leads should be equipped at their free ends with a 50-ampere power clip (Type PC).
- "Electrical Shock Damage — Do Not Touch Energized Circuits" warning signs should be mounted above the workbench.

These are some of the more readily apparent items. To be absolutely sure that you have the right workbench and that it's complete, you should review the guidance for electronic/electrical workbenches provided in General Specifications for Ships (GENSPECS); Shipboard Bonding, Grounding and Other Techniques for Electromagnetic Compatability and Safety (MIL-STD-1310D); and NAVORD Drawing 63-A-114J. Figure 1 is a simplified version of this drawing. Your particular installation will depend upon factors such as workbench location and utilization.

If you find that you do have an authorized workbench, remember that any modification that defeats the purpose of the insulation, such as attachment of vises, locks or hasps, makes the workbench unsafe for electrical work. Attachments should be made in such a manner that there are no metal interfaces between the attachment through the insulation to the metal frame of the workbench.

If the insulating qualities of the workbench are compromised, the workbench should be considered a general workbench, and additional safety precautions should be taken prior to the performance of any electrical work upon it. Posting of signs stipulating additional precautions is highly recommended.■

Figure 4A A Standard Navy Electrical/Electronics Workbench

4.7.2. Workbench Wiring, Grounding, and Lighting

a Electrical wiring to permanently installed workbenches shall be in conduit and shall include a green insulated grounding conductor.

c. A grounding bus with suitable attachment cables shall be provided to ground equipment serviced at workbenches. The grounding bus shall be connected to the (green insulated) grounding conductor (the fault protection subsystem) only by the main bonding jumper at the service entrance. Exposed metal parts of the workbench which could become energized by contact with live equipment shall be similarly grounded by connection with the grounding bus. Equipment grounding straps connected to the grounding bus shall be provided every four feet along the workbench surface and shall be equipped at their free ends with a 50 ampere power clip (type PC).

d. The impedance between the grounded neutral and the green wire grounding conductor when measured with a ground impedance tester shall be less than 0.5 ohms. The impedance between the grounding bus and the grounding conductor shall be less than 0.1 ohm.

e. Use isolation transformers when necessary to prevent shock from transformerless equipment.

f. Any outlet voltage and frequency other than nominal 120 vac, 60 Hz, shall be so labeled and the outlet device shall be of an approved type.

g. Any power with Military Standard (MS) type power connectors shall have different dedicated power cables to ensure that polarization of the connectors is unique to each different individual equipment safety ground and power connection. Each dedicated power cable and connector shall be labelled to indicate polarity and ground pins..

h. To minimize fire hazards, circuit breaker disconnects at the power panel shall be rated at not more than 20 amperes unless equipment power requirements so dictate. Any power strips installed or used at workbenches shall incorporate overcurrent protection.

i. Workbench power panel disconnects shall be identified by labels at the power panel. Workbench outlets shall also be labeled to identify the power panel and circuit breaker that controls power to those outlets. All of the disconnect switches for a workbench shall be located together. A single circuit breaker shall be provided at the power panel for control of power to all outlets of the same voltage and frequency at each workbench.

j. Ground fault circuit interrupters (GFCI) (Class A type, 5 mA trip rating) shall be installed on ac outlets on workbenches. AC receptacles not protected by a GFCI may also be provided only as needed for use with Navy approved equipment whose leakage current may cause the GFCI to actuate. Portable electric tools shall always use GFCI protected outlets. All outlets protected by the GFCI shall be labelled.

k. Lighting in workbench areas shall be no less than 100 footcandles.

4.7.3. Signs

There are three types of signs which should be posted near each workbench as appropriate.

a. Warning signs. When working on energized circuits and the possibility exists of unknowing personnel coming in contact with hazardous voltages post a

warning sign which in effect states: "DANGER. ELECTRICAL SHOCK. DO NOT TOUCH. ENERGIZED CIRCUITS." Similary if other potential dangers exist such as laser radiation from fiber optics or other lasers, or rf/microwave radiation hazards post the the appropriate warning sign and barriers to prevent personnel access.

b. Rescue signs. "INSTRUCTIONS FOR RESCUING PERSONNEL IN CONTACT WITH ENERGIZED CIRCUITS. WARNING. DO NOT ATTEMPT TO ADMINISTER FIRST AID TO OR COME IN PHYSICAL CONTACT WITH AN ELECTRIC SHOCK VICTIM BEFORE THE VICTIM HAS BEEN SEPARATED FROM THE VOLTAGE SOURCE. (1) TURN OFF THE VOLTAGE. IF THE VOLTAGE CANNOT BE TURNED OFF, USE AN INSULATED AXE IF POSSIBLE TO CUT THE CONDUCTORS. (2) IF THE VOLTAGE CANNOT BE DEENERGIZED, USE A DRY BOARD, BELT, DRY CLOTHING, OR OTHER AVAILABLE NONCONDUCTIVE MATERIAL TO FREE THE VICTIM FROM THE VOLTAGE SOURCE. DO NOT TOUCH THE VICTIM UNTIL THE VICTIM HAS BEEN SEPARATED FROM THE ENERGIZED CIRCUIT. (3) AFTER THE VICTIM HAS BEEN SEPARATED, BEGIN CPR IF APPROPRIATE." Post adjacent to the workbench a sign giving CPR instructions. See paragraph 2.2.2.6.2 for national stock number.

c. Prohibition signs. (If the workbench is designated for nonenergized work only) "THIS WORKBENCH IS NOT SAFE FOR WORK ON ELECTRICALLY ENERGIZED EQUIPMENT."

5.0 RADIO FREQUENCY (RF) AND MICROWAVE HAZARDS

5.1. Introduction. Radio and radar transmitters on ships, aircraft and ashore, RF heat sealing machines, and microwave ovens are potential sources of harmful radiation. Radiation of electromagnetic waves in the radio-frequency (RF) range can create hazards in various ways depending on the frequency and power of the incident wave and on the nature and configuration of the receiving object. Of particular concern is the possibility of injurious heating of the human body upon exposure to electromagnetic radiation and the induction of voltages in metallic structures and objects which, under optimum conditions, may result in the propagation of RF arcs and the initiation of electroexplosive devices. These hazards may be classified into three categories: hazards to personnel, hazards to flammable vapors, and hazards to ordnance. The technology involved in the assessment of the hazards in any particular radio frequency problem being beyond the scope of this manual, general safety personnel are advised to consult with cognizant electronic engineers.

The control of radio frequency and microwave hazards shall be accomplished in accordance with OPNAVINST 5100.23 Series, Chapter 22 and with NAVSEA OP3565/ NAVAIR 16-1-529/SPAWAR 0967-LP-624-6010 Technical Manual, Electromagnetic Radiation Hazards to Ordnance, Personnel and Fuel.

Figure 5.1 through 5.6 provide several examples of RF radiation hazard warning signs.

The following discussion of the principal hazards involved are presented in general terms to provide safety personnel with sufficient information for the recognition of possible hazardous conditions.

5.2. Hazards to Personnel

Radio-frequency electromagnetic radiation can be hazardous to personnel in two ways. One way is by direct exposure to high density radiation where the body may be damaged by heat. A second way is by exposure to electric shock and burns caused by RF potentials induced in metal objects that may be touched by personnel.

5.2.1. Radiation Hazards to Personnel. Transmitting antennas of most radar and high-power communication installations are generally located at heights above normal work areas. The greatest potential danger exists when personnel work anywhere within the radiation pattern. Signs that warn personnel of RF radiation hazards should be placed at eye level at the foot of the ladder or other access means to all towers, masts, rooftops, or structures where hazardous levels of radiation occur or are likely to occur. Equipment shall be locked out or tagged to prevent accidental turn-on when personnel are working on antennas or in their radiation fields. In addition, the following precautions shall be observed:

(1) Visual inspection of feed horns, open ends of wave guides, and any opening emitting RF electromagnetic energy shall not be made unless the equipment is definitely secured for such an inspection.

(2) Exposure will be avoided in all areas where the radiation power levels are in excess of those permitted by OPNAVINST 5100.23 Series, Chapter 22. Safe distances from certain radar antennas are listed in NAVSEA OP3565/NAVAIR 16-1-529/SPAWAR 0967-LP-624-6010 Volume I.

Radiation Symbol - Black
Outline - Checkerboard Red and Yellow
Lettering - Black

Figure 5.1. Recommended RF Radiation Warning Sign Specifications.

Figure 5.2. Example 1 of a Personnel RF Radiation Warning Sign.

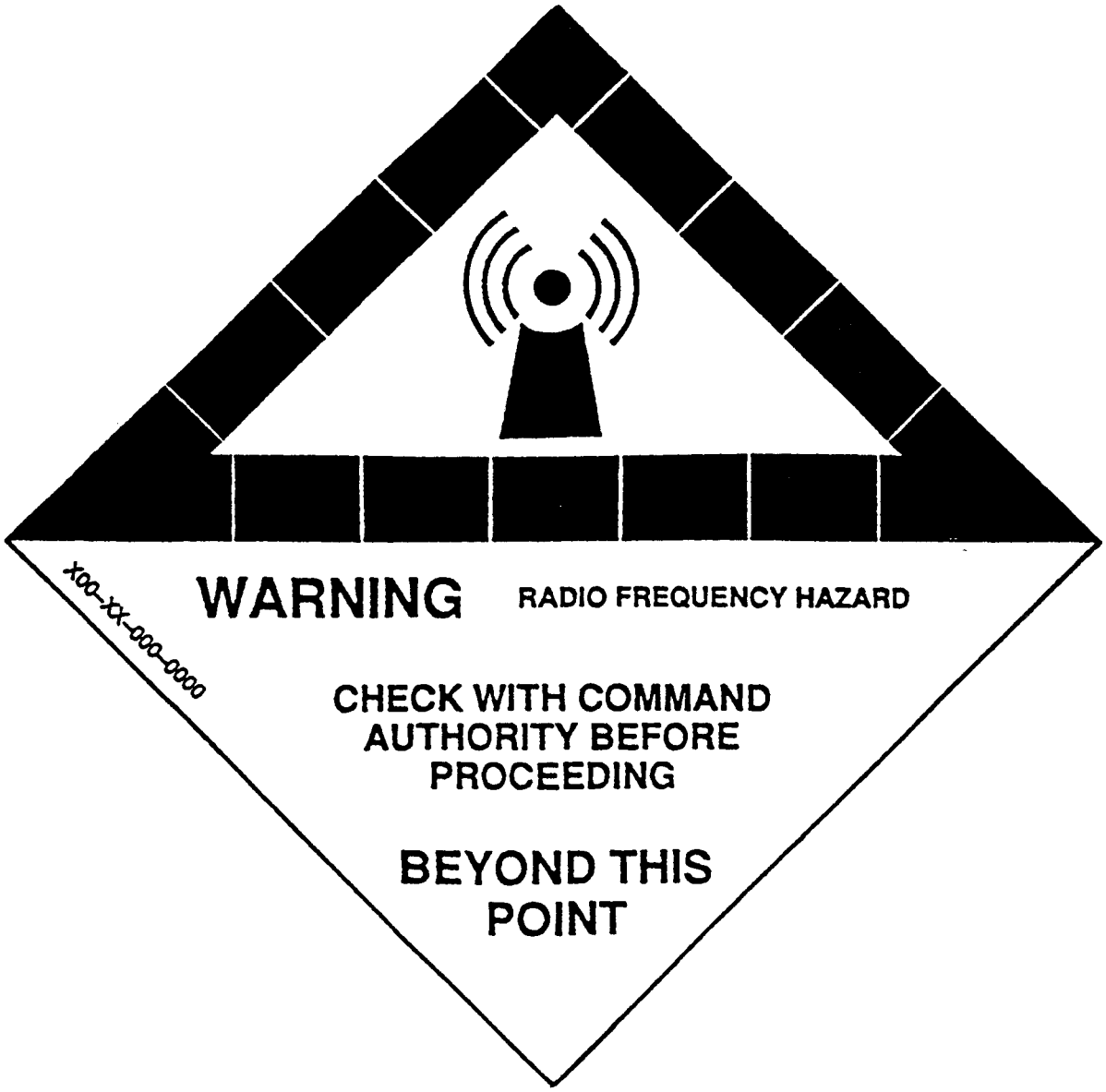


Figure 5.3. Example 2 of a Personnel RF Radiation Warning Sign.

Figure 5.4. An Example of a Personnel RF Burn Hazard Warning Sign.

Figure 5.5. An Example RF Radiation Hazard to Fuel Warning Sign.

Figure 5.6. An Example RF Hazard to Ordnance Warning Sign.

(3) Dummy loads shall be used where practicable during tuning, testing, or repairing RF transmitting equipment.

(4) Where test procedures require free space radiation, the radiating device will be positioned so as to prevent pointing the beam towards personnel or inhabited structures. In the positioning of such radiating devices, care will be taken not to direct or reflect either the primary beam or the secondary lobes in such a manner as to expose personnel to radiation.

(5) Aircraft employing high power radars shall be parked, or the antenna rotated, so that the beam is directed away from personnel working areas and any reflective surface.

(6) Train and elevate nonrotating antennas away from inhabited areas while radiating.

(7) Ensure that antennas which normally rotate are rotated continuously while radiating or are trained on a known safe bearing.

(8) Radars shall not be operated within the confines of a hangar or shop (except into a dummy load) unless the antennas are directed into a suitable absorbing screen or into an open area free of personnel or nearby reflective surfaces and only after it has been established by measurement that a hazard will not exist. Note that some windows may reflect hazardous levels of RF radiation back into a work space.

(9) When it is necessary to radiate hazardous levels of RF energy, appropriate RF warning signs shall be posted and entrance into such areas shall be prohibited.

(10) Where the possibility of accidental exposure might still exist, have a man stationed topside, within view of the antenna (but well out of the beam) and in communication with the operator, while the antenna is radiating.

(11) In areas where personnel must frequently pass near an antenna that is known to produce hazardous levels of radiation and it is not practical to secure radiation from the antenna, an RF screen or shield may be constructed. When properly designed, this screen provides a safe zone in which personnel may pass or work. Assistance in proper shield design may be obtained from the Naval Electronic Systems Engineering Center, Charleston, SC.

(12) All one killowatt and above transmitters shall be checked bimonthly to determine if any leakage is present. Transmitters shall also be checked after any extensive maintenance before they are brought up to full power. Records shall be made of these readings and kept on file in accordance with occupational safety and health regulations.

(13) Evaluate all RF radiators using the procedures of ANSI C95.3. Establish and control restricted areas. Conduct general and annual refresher courses for affected personnel. Include in the training data on evaluation findings, exceptions, and additional protection measures to be followed.

5.2.2. Hazards Due to Burns or Electric Shock in RF Fields.; RF potentials induced in nearby metal objects may be sufficient to cause deep painful burns or electric shock when contacted by unprotected parts of the body. Although usually insufficient to electrocute personnel directly, the shock may cause the person involved to react violently and thereby cause injury due to falling or striking some object. Examples of metallic objects that may have

sufficient RF voltage induced in them to constitute an RF burn or electric shock hazard are as follows:

Uninsulated cargo hooks

King posts

Smokestack guys

Railings

Aircraft

Lengths of wire cable

Antennas

Weapons launchers

Perimeter fencing

Large vehicles

Personnel working near such objects should be aware of the potential hazard and wear gloves and ground the objects when possible. It should be noted that a single ground, or several grounds, do not necessarily provide an RF ground for all surfaces of a large metallic object. Burn hazards may exist if RF voltages exceed 140 volts as measured with an RF voltmeter.

5.3. RF Hazards to Flammable Vapors. The increase in radiated RF energy from high powered communications and radar installations now used in the Navy has increased the potential hazard of RF arcs causing ignitions of flammable vapors. Such ignitions are dependent upon optimum vapor-air mixtures, proximity of flammable liquid handling operations to the radiating source, configuration of equipment involved, and frequency and power of the RF radiation. Detailed discussion of these optimum conditions and appropriate precautions are contained in NAVSEA-OP3565/NAVAIR-16-1-529/SPAWAR-0967-LP-624-6010 Volume I.

5.4. RF Hazards to Ordnance. Radio frequency electromagnetic radiation can cause accidental firing of electroexplosive devices used for initiating booster rockets, warhead detonation, and other purposes. Grounding or shorting of the electroexplosive device is not sufficient to assure safe handling in areas where RF electromagnetic radiation exists. The precautions to be followed in avoiding such accidental ignitions are contained in NAVSEA OP3565/NAVAIR 16-1-529/SPAWAR 0967-LP-6010 Volume II.

5.5. RF Heat Sealers. RF heat sealers must be so enclosed as to prevent RF exposure in excess of that specified by OPNAVINST 5100.23 Series, Chapter 22.

5.6. Working on Antennas. OSHA Standard 29 CFR Part 1910.268 and prior sections of this manual discuss shutdown, tagging, grounding, climbing, safety equipment, etc. for antenna work. The following additional precautions must be followed:

a. Cautions to personnel. Supervisors shall caution all personnel not to venture or work close to an exposed radio or radar antenna unless it is first determined from the proper authority that the antenna is not and will not be energized.

b. Danger from rotating antennas. Radar and other antennas which rotate or swing through horizontal or vertical arcs may cause persons working aloft to fall. Therefore, the motor switches which control the motion of these antennas shall be secured or locked in the open position and suitably tagged before anyone is permitted to ascend or go within reach of the antenna.

c. Antenna poles. Antenna poles shall be secured by antenna pole guys in accordance with "climbing of antenna poles" in OSHA standard 29 CFR Part 1910.268.

d. Aircraft antennas. Before operating transmitters in aircraft, an inspection shall be made of the antennas to insure that they are not touching fabric-covered portions of the aircraft parked nearby, and are not within hazard range of personnel, fuels, or ordnance.

6.0. INFRARED HAZARDS

a. Infrared (IR) radiations extend from the limit of the visible red region of the electromagnetic spectrum to the upper edge of the microwave region. Infrared rays are not visible to the human eye, and special equipment is required to detect and indicate the presence of these radiations. Infrared radiations have characteristics similar to those of visible light in that they can be reflected by mirrors and refracted.

b. Infrared equipment can be used in either active or passive applications. Active IR transmitters radiate energy which is reflected from a target and detected by a receiver. Passive IR receivers detect IR rays emitted by the object itself. Active IR applications present the greatest danger to the technician. One should avoid being exposed to the beam of an IR transmitter. Usually, the danger is not great because the heating effects of the beam can be felt before damage occurs. However, the eyes can be damaged before physical heating provides sufficient warning. Regardless of the type involved, all active-type IR transmitters should be regarded as potential hazards and all personnel should avoid looking into a source of IR radiation.

c. Infrared source hazard evaluations and recommended safety precautions may be obtained from the Navy Environmental Health Center (NEHC) or Naval Surface Warfare Center (NAVSWC Code H11) using the American Council of Government Industrial Hygienists (ACGIH) Threshold Limit Values (TLV).

7.0 LASER HAZARDS

7.1. Introduction. A laser is an instrument which generates a highly concentrated light beam (ultraviolet, visible, or infrared) which may produce considerable heat when absorbed by any material. The name is an acronym derived from the phrase "light amplification by stimulated emission of radiation."

The technology involved in the assessment of laser hazards in any particular application being beyond the scope of this manual, general safety personnel are advised to consult with their cognizant laser system safety officers (LSSOs) or COMSPAWARSYSCOM (00F). The necessary general and theoretical safety information is detailed in SPAWARINST 5100.12 series, BUMEDINST 6470.2 series, ANSI Z 136.1, E0410-BA-GYD-010/7034 Technical Manual, Laser Safety, NAVSEA OP3565/NAVAIR 16-1-529/SPAWAR 0967-LP-624-6010, and OPNAVINST 5100.23B. Military exempt lasers (those used exclusively for combat, combat training, or classified in the interest of national security) are addressed in SECNAVINST 5100.14 and SPAWARINST 5100.12 series.

The following discussion is presented to provide safety personnel with sufficient information for the recognition of possible hazardous conditions.

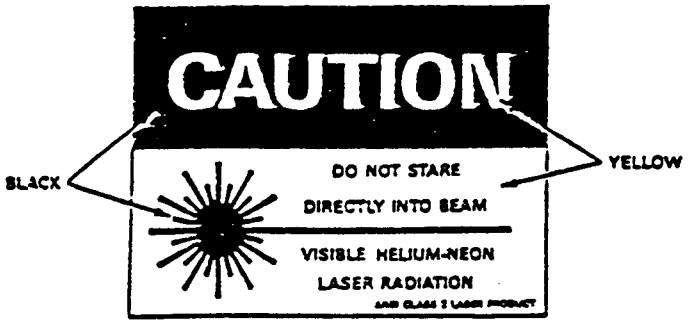
7.2. General Requirements. Lasers for industrial and military operations shall not be used without the express safety approval of COMSPAWARSYSCOM (00F) in accordance with SPAWARINST 5100.12 series and E0410-BA-GYD-010 Technical Manual, Laser Safety. All laser products and lasers which are produced after 2 August 1976 except Military Exempt Lasers (see SECNAVINST 5100.14B) must comply with the Radiation Control for Health and Safety Act, Code of Federal Regulations Title 21 (21 CFR) Subchapter J Part 1040. The procedures for the use of lasers are contained in ANSI Z136.1 "American National Standard for the Safe Use of Lasers." The following are some of the essential requirements of these standards to be followed at all Navy installations.

a. All personnel in areas where lasers are used shall be informed about the potential hazard associated with accidental exposure to this form of radiation. In particular, stress should be given to the extraordinary danger of eye damage due to the optical amplification and efficient absorption by this organ. Class III and IV lasers defined below may also cause skin damage or damage to material by fire or explosion due to rapid heating from a focused beam. Laser Safety training materials are available such as videos 804245DN "Laser Hazards and Control, and 804246 DN "Hazards and Control of Military Lasers".

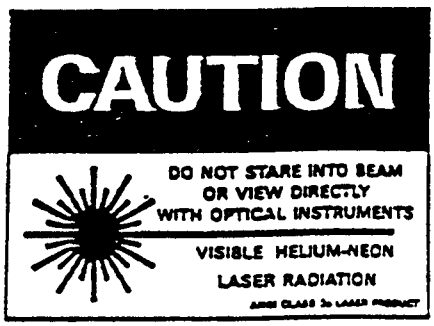
b. All commercial lasers must be classified (with Roman numerals) and labeled in accordance with 21 CFR Part 1040 and all military exempt lasers must classified (with ANSI Z136.1 Arabic numerals), and labelled in accordance with MIL-STD-1425 in one of the following four categories (See figures 7.1 and 7.2):

Class I Lasers -- Lasers which by inherent design cannot emit radiation levels in excess of the maximum permissible exposure (MPE) limits (safe limits are defined for each wavelength and emission duration). No Caution labels are required.

Class II Lasers -- Low power, visible light lasers and laser systems which can emit a power exceeding the MPE but not in excess of 1 milliwatt. These lasers stimulate eye reflexes which generally cause a person to turn away from the beam before eye damage is done. The signal word "CAUTION" shall be used with all signs and labels associated with the Class II lasers.



(a)

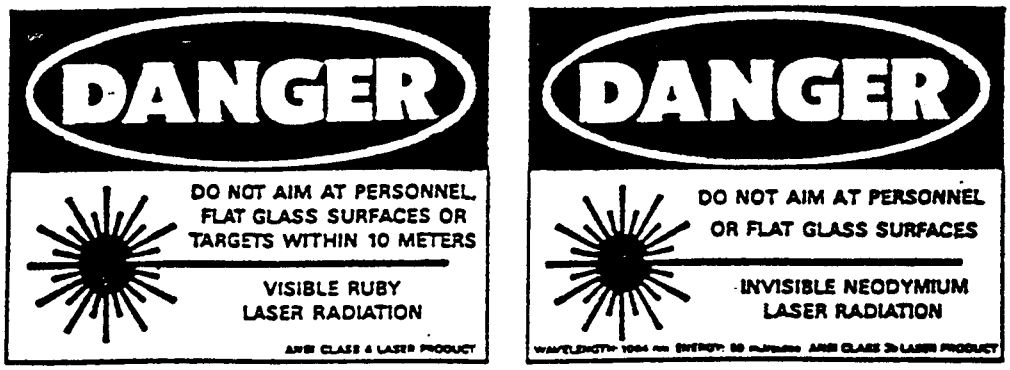


(b)

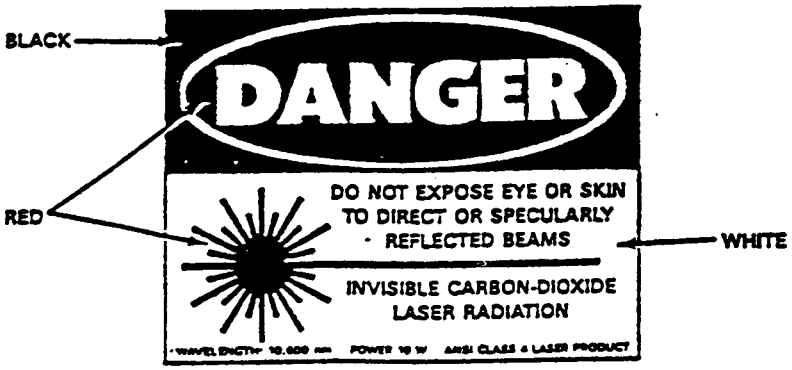
(c)

Examples of Laser Warning Labels: (a) Class 2
(b) Class 3a Visible and Near Infrared, and
(c) Class 3a Infrared and Ultraviolet

Figure 7.1 Examples of Laser Hazard Warning Labels.



(a)



(b)

Examples of Laser Warning Labels: (a) Class 3b and Class 4 Visible and Near Infrared, and (b) Class 3b and 4 Infrared and Ultraviolet

Figure 7.2 Examples of Laser Hazard Warning Labels.

Class IIIa Lasers -- Lasers which emit between 1 and 5 milliwatts total output power and also stimulate eye reflexes that cause persons to turn away before damage occurs. The direct beam must not be viewed with optical aids. Signal word "CAUTION" is usually used with these lasers. Class IIIa lasers which are labeled with the word "DANGER" emit in excess of 2.5 milliwatts per square centimeter and shall be treated as Class IIIb lasers.

Class IIIb Lasers -- Medium power lasers and laser systems. For example, visible lasers with less then 0.5 watts power output or 10^{-3} joules/cm^2 output for a 10^{-9} second pulse width and infrared lasers with less than 0.5 watts power output or less than 10 joules/cm^2 output energy for a pulse width between 10^{-9} and 1.0 second. Direct and specularly reflected beams of class IIIb lasers are hazardous but the diffuse reflection is not, provided the beam is not focused. The signal word "DANGER" shall be used with all signs and labels associated with the Class IIIb laser.

Class IV Lasers -- High power lasers and laser systems. This includes all lasers in excess of Class III limitations. The signal word "DANGER" shall be used on all signs and labels associated with the Class IV laser.

c. For all invisible radiation (less than 400 nanometers or greater than 700 nanometers) the word "INVISIBLE" shall precede the word "RADIATION" on all warning signs and labels.

d. Each Class II, III, and IV laser product must state on the warning label attached to the device, the maximum output of laser radiation, the pulse duration when appropriate and the laser medium or emitted wavelength. Examples of laser hazard warning signs are shown in Figures 7.1 and 7.2.

e. 21 CFR Part 1040 requires that all laser protective housings be interlocked. When the protective housing containing the laser beam is not interlocked or is defeatably interlocked, a warning sign must be provided stating "CAUTION" or "DANGER" with appropriate information concerning the hazard involved.

f. Each Class IIIb or IV laser must have a remote control connector with no more than 130 volts rms on the connector and a key actuated master control.

g. Each Class II, III, or IV laser must have an emission indicator which provides a visible or audible warning signal during laser radiation emission in excess of the maximum allowable safe limits. The warning signal must not cause personnel to inadvertently look into the laser beam or reflected radiation from the target.

h. All lasers and laser beams must be contained within a suitable controlled equipment or space (one which prevents access to the direct beam or its specular or hazardous diffuse reflection) so that uninformed personnel who may be casually in such an area cannot be accidentally injured. Laser beams emitted by an unenclosed system must be terminated at the end of the useful beam path if the exposure level is greater than the maximum allowable level. The backstop shall be of material that will absorb the particular wavelength. Special care in absorbing and containing the laser radiation must be taken especially when the laser is emitting energy in the ultraviolet or infrared portions of the spectrum since an observer might receive damage to the eyes without being aware of the reflection.

i. Only authorized personnel shall operate laser systems.

j. Spectators shall not be allowed access to the laser controlled area unless appropriate supervisory approval has been obtained and protective measures taken.

k. Direct viewing of laser beams even during optical alignment is prohibited. Viewing through attenuating material that limits the radiation to levels below the MPE (Maximum Permissible Exposure of ANSI Z136.1) may be performed with permission of supervisory personnel.

l. Optical systems such as lenses, telescopes, etc., will increase the hazard to the eye and may be used only when an appropriate filter is used to attenuate the radiation to levels below the MPE.

m. All personnel involved should be trained to avoid looking directly at an operating laser or its reflection. Personal protective equipment specifically designed and so marked for protection against radiation from the laser system shall be used when engineering or procedural controls are inadequate to eliminate radiation levels in excess of the MPE. Laser protective eyewear is usually the only type of protection required. However when working with ultraviolet wavelengths or some high energy lasers, the skin must also be protected. Laser protective eyewear shall be marked with optical density values and wavelength for which protection is afforded. The eyewear shall provide a snug fit. Periodic inspections of the goggles shall include: a) inspection of the attenuator material for pitting, crazing, cracking, etc., and b) inspection of the goggle frame for mechanical integrity and light leaks. Frequency of inspection is determined by the local Laser System Safety Officer.

n. At least two persons should be present at all times when lasers are in operation. Where the operation allows, a countdown procedure should be followed to minimize unnecessary potential exposure by forewarning personnel to take necessary protection from the radiation by donning protective goggles, etc.

o. Reflecting surfaces such as mirrors, glass bottles, windows and metal or other surfaces which have a high coefficient for specular reflection shall be eliminated from the beam path or shall be faced and/or surrounded with diffuse substances to absorb the energy. One of the most serious eye injuries incurred from laser radiation to date resulted from a specular reflection from a glass bottle.

p. Personnel shall not look into the open end of an optical fiber unless power to the laser or light emitting diode has been disconnected. When LED or laser power cannot be secured during maintenance, a hazardous area of at least one meter shall be established around the open fiber.

q. Hazardous by-products may result from the reaction of the laser radiation especially ultraviolet laser radiation, with air and other substances, for example formation of ozone, skin irritation agents, etc.

r. Field operations for Class IIIb and Class IV lasers shall not be permitted until the application has been reviewed and certified for safety by a technically qualified laser system safety officer (LSSO) or SPAWARSYSCOM (SPAWAR 00F).

s. Other hazards in laser installations may arise from the use of cryogenics, compressed gases, toxic material, noise, arc or filament lamps and targets which may shatter, ionizing radiation and incoherent optical and

ultraviolet radiation from laser discharge tubes or flash lamps and electrical hazards. Proper personnel protection and procedures shall be provided in the use of cryogenics. Compressed gas bottles shall be secured. All laser discharge tubes or flash lamps, the laser target, capacitors and all elements of the optical train which may shatter shall be adequately contained. All incidental radiation shall be adequately shielded. The laser spaces shall be adequately ventilated to remove toxic gases. All toxic materials shall be marked and adequately controlled. Smoking, eating or drinking in laser areas should be prohibited. Adequacy of these hazards controls shall be determined by the local LSSO and industrial hygienist.

t. Personnel working with Class III or Class IV lasers shall receive an eye examination prior to participation in laser work, after completion of laser work, or immediately after suspected laser eye injury in accordance with NAVMEDCOMINST 6470.2 and ANSI Z136.1.

u. Suspected overexposure to laser radiation must be reported to the medical department immediately.

7.3. FIBER OPTICS. Fiber optics are thin transparent fibers of glass or plastic that transmit light throughout their length by internal reflections. A common use of this technology is in the design of optical fiber communication systems (OFCS). OFCS products use laser diode transmitters, light emitting devices (LEDs), or both in their design. Typical average output power levels of laser diodes and LEDs are less than 500 mw. Wavelengths are between 0.4 micrometers and one millimeter. Under normal operating conditions, optical radiation from these devices is confined to the fiber core and therefore inaccessible to the user. But they can emit sufficient power from disconnected or broken cables to injure the eye. Injury is most likely when an optical connector is removed during service and an optical instrument such as an eye loupe, hand magnifier, or a microscope is used to view the end of an energized fiber. Another hazard involves use of lens connectors. Since the emission pattern of a diode laser or LED is highly divergent, a lens connector may be used when coupling optical cables to decrease the divergence. As a result, the hazard associated with the use of lens connectors may be considerably greater than that of conventional connectors. In fact, inadvertent exposure of the unaided eye to a primary or specularly reflected beam from an unterminated energized non-lens connector at distances greater than one meter from the connector normally will not cause eye injury. The procedure of viewing such a connector without adequate eye protection, however, should be avoided, since it can develop into a potentially dangerous habit.

For detailed information, consult ANSI Z136.2, "American National Standard for the Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources."

7.3.1. Optical Fiber Communication System (OFCS) Classes

The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an OFCS is inherently an eye safe system. But when an optical fiber connection is broken and optical instruments are used, it is possible that hazardous energy can enter the eye. For this reason, four service group (SG) hazard classes have been devised to indicate the degree of hazard and required hazard control measures associated with OFCSs. These definitions are based strictly on the optical radiation hazard and do not take into account other potential hazards. The information which follows is no more than a brief description of each class. Refer to ANSI Z136.2 for a full technical definition.

a. SG1: An OFCS is classified Service Group 1 if the laser or LED cannot emit accessible levels of optical radiation in excess of the maximum permissible irradiance (MPI) levels. A SG1 OFCS is exempt from all control measures and from any form of surveillance.

b. SG2: An OFCS is classified Service Group 2 if the laser or LED emits in the visible (0.4 - 0.7 micrometers) spectrum a total accessible radiant power exceeding the MPE but not in excess of one milliwatt. These low power visible OFCSs stimulate eye reflexes which generally cause a person to look away from the beam before eye damage occurs even when optical aids are being used. The word "CAUTION" should appear on all SG2 labels and signs.

c. SG3a: An OFCS is classified Service Group 3a if the laser or LED beam at a visible wavelength stimulates the eye reflexes to turn the eye away before injury occurs. If optical aids are in use, however, this reflex will not provide adequate protection. Similarly for an invisible wavelength, a Service Group 3a laser would be one where an individual would not normally stare into the beam for a period beyond which the radiation would be hazardous, normally 10 seconds. The word "CAUTION" should also appear on all SG3a labels and signs.

d. SG3b: An OFCS is classified Service Group 3b if the laser or LED poses a hazard to the eye when the direct or specularly reflected beam is viewed with or without optical aids. SG3b OFCSs are considered medium power devices. The word "DANGER" should appear on all SG3b labels and signs.

e. A label shall be posted on each Service Class (SC) 2, 3a, and 3b OFCS which indicates the maximum output of laser radiation, the pulse duration when appropriate, and the active medium or emitted wavelength.

f. For all invisible radiation (less than 400 nanometers or greater than 700 nanometers) the word "INVISIBLE" shall precede the word "RADIATION" on all warning signs and labels.

7.3.2. Safe Work Practices for OFCS

The following safety practices shall be applied when installing, using, or servicing OFCSs:

a. Provide initial and recurrent training appropriate to the level of risk present.

b. Ensure that the system has been classified by the manufacturer in accordance with ANSI Z136.2 and that all components whose removal would allow access to levels of optical radiation greater than the accessible emission limits of Service Group 1 are properly labeled and easily readable.

c. Comply with the service control and medical surveillance measures defined by ANSI Z136.2 for the particular system.

d. To verify continuity of optical fibers, use an appropriate optical test set. Viewing the end of a fiber that is suspected to be energized should only be done with an indirect image converter or similar device. Verifying continuity of optical fibers by shining a flashlight into one end and viewing the other end is not recommended.

e. Do not examine or stare into broken, severed, or disconnected optical cables. Arrange for a trained service person to repair or replace the cable.

f. Since an OFCS test set is itself an OFCS device, apply all OFCS hazard

control measures also to the test set.

g. Do not view the primary beam or a specular reflection from an OFCS with an optical instrument. The instrument may create a hazard due to its light-gathering capability.

h. Control access to such OFCS installations as cable closets, patch panels, multiplexer cabinets, and network panel enclosures, especially during service or maintenance.

i. Establish a control area and proper controls after taking into account the following factors:

1. Location of OFCS.

2. Type of activity.

3. Extent of hazardous specular reflection.

4. Applicability of extended source criteria.

5. Personnel considerations, such as number, age, maturity, education, training, and experience.

j. Give priority to the use of engineering controls over administrative and procedural measures in controlling all applicable hazards.

k. Use eye protection when engineering and other administrative controls are insufficient to eliminate potential exposure beyond applicable maximum permissible irradiance levels.

l. When access panels or doors are removed or opened and the critical viewing distance could exceed 100 cm,(as may occur when lens connectors are employed) use means to contain the beam to preclude exposure of nearby personnel.

m. Be alert to the fact that ocular hazards associated with different wavelengths, pulse durations, and pulse frequencies are not the same. Detectors for measuring power may respond differently to different wavelengths. Calculations to determine the effect of superimposed pulses on a cw background are complex. Multimode beams may have a compounding effect instead of being simply linearly additive.

8.0. IONIZING RADIATION.

8.1. *X-radiation Hazards*. Modern electron tubes, such as high-power klystrons, magnetrons, thyratrons, cathode-ray tubes, and high voltage rectifiers, when operated with electric potentials in excess of 10,000 volts, may generate X-rays. These X-rays may emanate from the tube if satisfactory shielding is not provided. All X-rays, except those of very low energy, will penetrate human tissue and can cause damage which may be temporary or permanent, depending upon radiation level and exposure time. The following precautions shall be taken by electronic technicians when performing maintenance on equipment which can produce X-ray radiation:

a. Measurement. When working with high voltage electron tubes capable of producing X-rays, make certain that sources of radiation have been measured at all possible points of emission. Under normal operating conditions, there will probably be proper shielding for these tubes, but you should be aware of the possible increase in radiation under unusual conditions. Work areas exposed to radiation should be checked to determine the radiation levels and, if necessary, to set some time limits for workers in the area. The maximum permissible radiation level in any accessible area for members of the general public is given in NAVMED P-5055.

b. Warning Signs. Observe all warning signs on the equipment and all written safety precautions in the instruction manuals for the equipment that deals with X-ray hazards.

c. Interlocks. Do not use jumper interlocks that permit the servicing of operating equipment with the protective X-ray shielding removed, unless such procedures are called for in the instruction manuals, and then only with alternate equivalent safeguards.

d. Shielding. Replace all protective X-ray shielding when servicing is complete, so that operating personnel or others will not unknowingly be subjected to harmful X-ray radiation.

e. Bench Testing. When bench testing X-ray producing electronic devices, ensure that adequate X-ray shielding is provided to protect all personnel in the testing area.

f. Complete Precautions. Determine the latest safety precautions to be observed by consulting the local radiation safety officer or industrial hygienist.

8.2. *Radioactive Materials in Radiac Check Sources and Electron Tubes*. There is a large variety of radioactive material used in calibrating or checking radiac equipment. The use of the larger sources is restricted to authorized radiac repair facilities. Smaller sources, are supplied with equipment for the purpose of field checking the instruments. Proper use or handling of these sources is covered in the technical manuals for the equipment with which they are supplied. Electron tubes such as cathode-ray tubes, spark gap devices (e.g., TR and ATR tubes), power amplifier tubes, voltage regulators, cold cathode tubes, and some special purpose tubes may contain a small amount of radioactive material and may be marked in accordance with military specification MIL-STD-129. The concern in handling individual electron tubes containing radioactive material is primarily that of breakage and possible contamination of personnel and surrounding area with radioactive material and such hazardous substances as beryllium oxide.

Local radiation safety officers can supply additional guidance. In

storage, small quantities of radioactive materials in check sources and electron tubes do not present a health hazard but may expose unprocessed photographic and radiographic films and papers. More detailed information on the handling and storage of radioactive material and the safety precautions to be observed is contained in NAVMED P-5055, Radiation Health Protection Manual, NAVSUP 4000.34B, NAVSEA S0420-AA-RAD-010 (RAD-010), 10 CFR Part 20, and 49 CFR.

8.2.1. Handling

a. Use caution while handling tubes and radiac check sources.

b. Avoid storing large quantities of electron tubes in a small area since this will increase the likelihood of contamination in the event of multiple breakage.

c. To prevent accidental breakage, do not remove an electron tube from its carton until just prior to its installation.

d. Insert used tubes in the replacement tube container and obtain disposal instructions from the local radiation safety officer.

8.2.2.2. Breakage. A disposal kit should be available in the electronics maintenance shop and should contain such items as rubber gloves, forceps, gauze pads, water, masking tape, radioactive decal, chalk, surgical mask, and inventory sheet. In the event of breakage, approved methods of monitoring, decontamination, and disposal shall be employed. Under no conditions should unauthorized persons handle broken electron tubes containing radioactive material. Individual electron tubes containing one microcurie of cesium-137, cobalt-60 or carbon-14, two microcuries of radium-226 or three microcuries of nickel-63 do not present an external contamination hazard. However, the radioactive material can present an internal hazard if it is ingested, inhaled or otherwise gains entry into the body. Therefore, broken tubes should be cleaned up as soon as possible. Radiation Decontamination (RADDECON) monitoring must be performed any time radioactive material is released to the environment. RADDECON monitoring teams are available from the servicing environmental health service. Additional resources include U.S. Navy Tenders in port. With the exception of the monitoring team, no one should be allowed to enter or leave the space and nothing shall be removed from the space until the monitoring team has declared that the site is not contaminated. A monitoring team is not required for beryllium oxide contamination.
If breakage occurs:

a. Secure the area.

b. Notify the safety office/radiation safety officer. Provide them information on the location of the spill, the nature of any injuries, and type of assistance required.

c. Do not allow any parts of a broken tube to come in contact with any part of your body.

d. Do not breathe in any vapor or dust released by breakage.

e. Follow the instructions of personnel assigned radiation safety responsibilities for handling the broken pieces, decontamination of the area, and disposal of contaminated material, including cleaning materials. Large pieces of broken tubes may be carefully picked up and placed in a plastic bag. Small pieces should be carefully swept into a plastic bag and sealed. After sealing, the plastic bag containing the broken tube should be turned over to

the radiation safety officer for proper disposal. The area where the tube was located and materials used in the clean up should be surveyed for contamination, using an IM-247PD/DT-304.

f. Ensure personnel in the area are checked for radioactive contamination before leaving area.

8.2.2.3 Injury. In the event of an injury by a broken tube containing radioactive materials, the following rules apply.

a. Notify medical authorities. Treatment and decontamination procedures shall be in accordance with NAVMED P-5055, "Radiation Health Protection Manual." Obtain medical treatment.

b. When a wound is caused by a sharp radioactive object, mild bleeding should be stimulated by pressure about the wound.

c. Do not suck the wound by mouth.

d. Wash the wound with soap, and flush with plenty of clean water.

8.2.3. Disposal. Broken and useless tubes containing radioactive material should be treated as any other radioactive waste material and disposed of in accordance with instructions contained in NAVSUPINST 5101.9B and NAVSEA S0420-AA-RAD-010. Contact the local radiation safety officer (RSO) for further assistance.

8.3. Radioluminescent Materials. Paints and markers that glow in the dark can increase visibility at night. Radioluminescent materials are often used for this purpose. Usually, an alpha emitting radioactive material is combined with a phosphor. The alpha particles have such a short range that they ordinarily present no hazard. Any radioluminescent devices containing radium shall be reported to NAVSEA to determine handling, modification, or disposition instructions in accordance with NAVSEA S0420-AA-RAD-010.

9.0. ROBOTICS.

Robotics is the engineering technology by which reprogrammable manipulators are designed to perform a variety of tasks through variable programmed motions. As the technology of robotics grows, more routine, repetitive, monotonous, unpleasant, and hazardous jobs will be taken over by robots. Specific uses of robots have included material handling, tool handling, repetitive manipulations, welding, die casting, forging, press operation, spray painting, grinding and deburring, glass making, and handling of radioactive materials. In general, robots will be designed to assume whatever tasks the state of the art permits.

Although curiosity and complacency are two sources of human error, most robot problems appear to be due to machine failure rather than operator error. Robots can move in unexpected paths and at varying speeds. Historical trends indicate that most accidents occur while a robot is being trained or serviced, and that most hazards are due to impact, pinch, and release of an object by the robot's arm. With loss of power, not all robotic movement necessarily stops. Loads being carried can crash to the floor or become projectiles. The entire arm can swiftly fall onto whatever or whoever is underneath.

Self diagnostic and operational error checking functions have significantly reduced robot hazards, but they have been found to be of limited utility. ANSI R14.06, "American National Standard for Industrial Robots and Robot Systems - Safety Requirements," provides detailed guidance for the construction, installation, care, and use of industrial robots. The items below are primarily derived from the section on safeguarding. Another source is OSHA Instruction PUB 8-1.3, "Guidelines for Robotics Safety."

9.1. Responsibilities for Safeguarding

a. Barrier. Provide a barrier to prevent personnel from reaching over, under, around, or through the barrier into the restricted work envelope (the volume swept by all possible programmable robot movements). It shall be necessary to use tools to remove the barrier or its sections in order to gain entrance to the restricted work envelope.

NOTE: Posts or stanchions should not be used to halt a runaway because they could form pinch points -- areas in which personnel could be trapped and crushed.

b. Perimeter Guarding. Locate perimeter guarding so that personnel are prevented from inadvertently entering into any restricted work envelopes within the perimeter. The entrance shall be limited and located so that authorized personnel can enter the enclosed area without inadvertently entering a restricted work envelope. A prominent sign shall be posted at the entrance, stating that entry by unauthorized personnel is prohibited.

c. Awareness Barrier. If analysis so dictates, install an awareness barrier which will prevent a person from entering the restricted work envelope of a robot without sensing the presence of the barrier. The awareness barrier shall be located so as to prevent inadvertent entry into the restricted work envelope

d. Awareness Signal. If analysis so dictates, locate an awareness signal in order that it will provide a recognizable audible or visual signal to individuals of an approaching or present hazard. When awareness signals in the form of lights are used to warn of hazards in a restricted work envelope, sufficient devices shall be used and located so that the light can be seen by

an individual in the proximity of the work envelope. Audible awareness devices shall have a distinctive sound of greater intensity than the ambient noise level.

e. Awareness Signal Restrictions. Do not use awareness devices unless a hazard analysis of the robot system indicates that other methods of safeguarding are not feasible or warranted. As a single method of safeguarding, awareness devices are considered to be less effective than barriers and perimeter guarding.

f. EMI/RF Effects. Protect robots with electronic controllers from electromagnetic and radio frequency interference that could affect the controller and cause the robot to move erratically. Cables providing electrical control and feedback signals between system components should be shielded to preclude the introduction of induced false signal voltages.

9.2. Safeguarding the Operator

a. Ensure that safeguards are established for each operation associated with the robot system: The safeguards shall either prevent the operator from being in the restricted work envelope during robot motion, or prevent or inhibit robot motion while any part of an operator's body is within the restricted work envelope (for example, floor mats with imbedded weight-sensing shutoff switches may be placed in the work envelope to sense intruding personnel and shut down the robot).

b. Ensure that operators of robot systems are trained to recognize known hazards associated with each assigned task involving the robot system. Operators of robot systems shall be instructed in the proper operation of the control actuators of the robot system and shall be taught how to respond to recognized hazardous conditions.

9.3. Safeguarding the Teacher (Programmer)

a. Ensure that the teacher is trained regarding the particular installation, including the control program and the recommended "teach" procedures.

b. Before teaching a robot, visually check the robot and work envelope to assure that conditions that may cause hazards do not exist. The teach controls of the pendant shall be function tested to ensure proper operation. Any damage or malfunction shall be repaired prior to commencing the teaching operation.

c. Before entering the restricted work envelope, the teacher shall ensure that all safeguards are in place and functioning as intended in the teach mode.

d. When the teach mode is selected, ensure that the following conditions are met:

1. The robot system is under the sole control of the teacher.

2. When under drive power, the robot operates at slow speed only. An exception may be permitted when a speed greater than slow speed is provided for verification of a program. In that case, a deliberate action by the teacher to select a speed and constant actuation of the controls to continue robot motion shall be required.

3. The robot shall not respond to any remote interlocks or signals

thatwould cause motion.

4. Movement of other equipment in the work envelope shall be under the sole control of the teacher if such movement would present a hazard.

e. Leave the restricted work envelope prior to initiating automatic mode.

f. Allow no one other than the teacher in the restricted work envelope.

9.4. Safeguarding Maintenance and Repair Personnel

a. Ensure that personnel who perform maintenance or repair on robots are trained in the procedures necessary to safely perform the required tasks.

b. Ensure that personnel who maintain and repair robot systems are safeguarded from injury due to unexpected or unintended motion.

c. If possible, shut down the robot (in general the most effective method) as a means of safeguarding. A procedure shall be followed that includes lockout/tagout of sources of power and releasing or blocking of potentially hazardous stored energy.

d. If entry for maintenance and repair cannot be accomplished with the system deenergized, then prior to entering the restricted work envelope while power to the robot is on, perform the following procedures:

1. Visually inspect the robot to determine if any conditions exist that are likely to cause malfunctions.

2. If pendant controls are to be used, function test the controls prior to such use to assure their proper operation.

3. If any damage or malfunctioning is found, make required corrections and retest before personnel enter the work envelope.

e. Ensure that total control of the robot is in the hands of personnel performing maintenance or repair tasks within the restricted work envelope when drive power is available. Accomplish this goal by ensuring the following:

1. Remove control of the robot from automatic operation.

2. Isolate robot control from any remote signals that could initiate robot motion.

3. Place movement of other equipment in a robot system under the control of the person in the restricted work envelope if such movement would present a hazard.

4. Ensure that all robot emergency stop devices remain functional.

5. Permit the robot to be reset for automatic operation only after all personnel have left the restricted work envelope.

f. Use the following methods of safeguarding when appropriate:

1. To avoid exposing maintenance personnel to a trapping point, place the robot arm in a predetermined position.

2. Use devices such as blocks or pins to prevent potentially hazardous movement of the robot.

3. When a second person is stationed at the robot control panel, ensure that this person is prepared to respond properly to the potential hazards associated with the robot.

g. If during maintenance or repair it becomes necessary to bypass safeguards required for automatic operation, provide equally effective alternative safeguards and identify or tag the bypass method. Return the bypassed safeguards to their original effectiveness when the maintenance task is complete.

9.5. Care. The user of a robot system shall establish a regular and periodic inspection and maintenance program to assure its continued safe operation. The user should be able to demonstrate that an effective inspection and maintenance program is in place. The inspection and maintenance program shall consider the manufacturer's recommendations.

9.6. Testing and Startup. The following procedures shall be followed during the testing and startup of robots after installation or relocation. They also apply to robots after changes in software or hardware and after maintenance or repairs that could affect their safe operation.

a. If the intended means of safeguarding are not in place prior to the testing and startup procedure, set up an interim means of designating the work envelope before proceeding.

b. During testing and startup, allow no personnel in the work envelope of the robot until safeguards and proper operation are verified.

c. Follow the manufacturer's instructions for testing and startup of the robot.

d. Include in the initial startup procedure, but do not necessarily limit the procedure to, the following verification process:

1. Before applying power, verify that the following have been installed as intended:

(a) Mechanical mounting and stability

(b) Electrical connections

(c) Utility connections

(d) Communications connections

(e) Peripheral equipment and systems

(f) Limiting devices for restricting the work envelope.

2. After applying power, verify that:

(a) Each axis moves and is restricted as intended

(b) Emergency stop devices are functional

(d) Drive-power disconnect functions

(e) Program executes as intended

(f) Interlocks function

(g) Safeguards function

(h) The maximum slow speed does not exceed 250 millimeters per second (10 inches per second).

(i) The speed of any individual axis does not exceed 250 millimeters per second (10 inches per second) in the event of any single, reasonably foreseeable malfunction.

(j) Automatic operation functions as intended.

e. Include in a procedure for the restart of the system after modification, repair, or maintenance of the hardware or program, but do not necessarily limit the procedure to, the following tests:

1. Check any changes or additions to the hardware system prior to applying power.

2. Function test the robot for proper system operation.

9.7. Training

a. Ensure that employees who program, teach, operate, maintain, or repair robots are adequately and properly trained.

b. Include review of applicable standard safety procedures and the safety recommendations of the manufacturers.

c. Integrate into every phase of the training, safety precautions and procedures that are specific to the installation and application of the particular robots in use.

10.0. VIDEO DISPLAY TERMINALS

10.1. Introduction. The National Institute of Occupational Safety and Health (NIOSH) has been studying the health effects of video display terminals (VDTs). The findings show that there are no radiation hazards resulting from work associated with a VDT, either to the operator or to a developing fetus. On the whole, the findings suggest that visual and musculoskeletal problems are the most frequent problems that VDT operators complain about, but these problems seem to be easily controlled with the use of ergonomic improvements. Whether long term use causes significant visual degeneration or dysfunction remains unknown. The matter requires further investigation.

10.2. Health Complaints and Psychological Status. The NIOSH study showed that the percentages of VDT operators and nonoperators reporting a specific health complaint were varied. The health complaints reported by a significantly higher percentage of VDT operators than nonoperators were primarily for emotional problems including anxiety, depression, irritability, tension, and gastrointestinal problems including gas pains, acid indigestion, and tight feeling in the stomach. In addition, operators also reported a significantly higher percentage of pain or stiffness in arms or legs, swollen or painful muscles and joints, and eye strain or sore eyes. It is quite likely that the emotional distress shown by the VDT operators is more related to the type of work activity than the use of VDTs.

10.3. VDT Workstation Design and Operation Requirements. The following is a discussion of the NIOSH recommendations to relieve physical and psychological stress to VDT operators. Values outside these ranges may be necessary based on the needs of individual operators.

10.3.1. Keyboard height. Excessive keyboard height can lead to musculoskeletal fatigue due to the operator's need to keep the hands in an elevated position. NIOSH recommends nominal keyboard heights from 28.3" to 31" resulting in an angle between upper and lower arm of between 80 degrees to 120 degrees (see figure 10.1) and further suggests that this height be adjustable to accommodate the worker. Detachable key boards on separate adjustable workstands will allow this adjustment.

10.3.2. View angle and brightness. Incorrect viewing angle can result in poor worker posture and worker fatigue. Screen height and position should be adjusted normally 10 degrees to 20 degrees below the horizontal plane of the operators eyes with the top of screen below eye level (see figure 10.1). Again, the one piece VDT units and the non-adjustable tables present difficulties in achieving this viewing angle. The operator should also be able to adjust screen brightness and contrast.

10.3.3. Viewing distance. Viewing distance is also important in minimizing visual fatigue. The optimum viewing distance is between 17.75" and 19.75" with a maximum distance of 27.5". Viewing distance should be equidistant to screen, keyboard and hardcopy.

10.3.4. Copy holders. All VDT workstations should be equipped with copy holders. The copy holder will decrease the range of neck movements and visual search of the operator. This will minimize muscle and visual fatigue. The copy holder should be positioned near the VDT screen but also be adjustable to accommodate the job task and worker variability.

10.3.5. Chair features. Operator chairs should be adjustable in seat pan height and backrest height and tension. Backrests should be adjustable to the

lumbar region (mid-back) to provide adequate support. Arm rests may be provided on the chairs but should be removable to accommodate the worker.

10.3.6. Operator posture. Preferred operator posture is for the operator to be seated erect, with the thoracic region of the spine convex, the lumbar region concave, the thighs horizontal and the feet flat on the floor. Footrests should be provided where necessary to relieve pressure from the seat front on the operators' legs.

10.3.7. Glare. Glare can impact the operator's ability to distinguish characters on the VDT screen. This can result in visual fatigue and can contribute to poor operator posture as the operator changes position to compensate for glare. These recommendations can help to limit glare:

a. Avoid the use of high reflectance, high gloss surfaces adjacent to the VDT.

b. Drapes, shades and/or blinds over adjustment windows should be closed, especially during direct sunlight conditions.

c. The VDT screens should be properly positioned with respect to windows, overhead lighting and individual workstation lighting, so that glare sources are neither directly in front of the operators, nor reflected in the VDT screen.

d. Screen hoods may be installed to completely or partially shield the screen from reflections. Screen hoods shall not be used where they force the operator to assume an uncomfortable posture to view the screen.

e. Anti-glare filters may be installed on the VDT screen. The characteristics and effectiveness of different types of glare filters vary widely and some screen filters may have detrimental effects on image quality or contrasts. Care should, therefore, be used in filter selection. Information on anti-glare filters is available from the following companies:

Polaroid Corporation, Cambridge, Mass.
Optical Coating Laboratory, Inc., Santa Rosa, Calif.
Sun-Flex Company, Inc., Novato, Calif.

f. Where a large number of lights are unavoidably positioned behind the operator, a combination of screen hoods and properly selected antiglare filters may decrease glare.

g. Direct lighting fixtures may need to be recessed and baffles used to cover light fixtures to prevent the light fixtures from acting as a glare source. Special covers may also be used on light fixtures to direct the light downward rather than allowing the light to diffuse.

h. Properly installed indirect lighting systems will limit the light fixtures' potential as glare sources.

10.3.8. Display and Hardcopy Legibility. While display and hardcopy legibility are also dependent on illumination and glare there are some other specific deficiencies that can affect operator visual fatigue.

a. Tube flicker, character jitter and character blurring can produce visual blurring as a result of continuous refocusing by the operator. These problems should prompt maintenance efforts immediately.

b. Smudges and fingerprints on the VDT screen can degrade display

legibility. The VDT screens should be cleaned as needed.

c. Because of the previously recommended compromise in illumination levels, hard copy used in VDT work areas should be of particularly high quality.

10.3.9. Work Rest Regimens. Based upon the concern about potential chronic effects on the visual and musculature system and prolonged psychological distress, NIOSH recommends the following work-rest breaks for VDT operators:

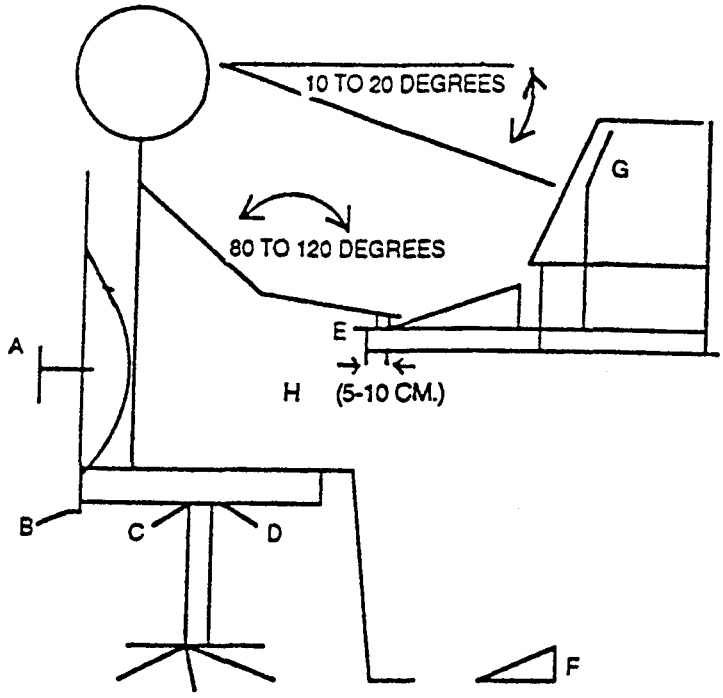
a. A 15-minute work-rest break should be taken after two hours of continuous VDT work for operators under moderate visual demands and/or moderate work load. Frequency and duration of breaks will be determined by the employee's supervisor. Guidance to supervisors will be provided by the Safety Office.

b. A 15-minute work-rest break should be taken after one hour of continuous VDT work for operators under high visual demands, high workload and/or those engaged in repetitive work tasks.

10.4. Visual Acuity. NIOSH recommends that VDT operators be given a pre-placement vision examination and a periodic follow-up vision examination to detect any vision degradation.

10.5. Illumination. As a compromise between VDT work and hard copy tasks, NIOSH recommends illumination values of 46 footcandles (fc) to 65 footcandles measured about 10 inches from the monitor screen between operator and monitor. If illumination of greater than 65 footcandles is necessary due to special work task demands, use of individual work station illumination is recommended.

NOTE: The values in all the above paragraphs are nominal values. The workstation should be adjustable to accommodate the individual physical characteristics of the worker. The following checklist may be used to assist in verifying individual workstation compliance keeping in mind the necessity of accomodating the individual worker.



A. ADJUST BACK REST UP OR DOWN TO SUPPORT LOWER BACK

B. ADJUST BACK SUPPORT SPRING PRESSURE TO RELAX BACK

C. ADJUST SEAT HEIGHT TO VIEW MONITOR AND REACH KEYBOARD WITHOUT STRAINING NECK OR WRISTS AND ALLOW FEET TO TOUCH FLOOR WITHOUT CUTTING OFF CIRCULATION TO THE LEGS.

D. TILT SEAT PAN FORWARD OR BACK TO MINIMIZE STRAIN ON THE TAILBONE.

E. PROVIDE A WRIST PAD IF THE WRISTS MUST STRAIN TO REMAIN SUSPENDED WHILE TYPING OR USING A MOUSE.

F. PROVIDE A FOOT REST IF CIRCULATION TO THE LEGS IS AFFECTED.

G. ENSURE THAT THE COPY HOLDER IS THE SAME DISTANCE AS THE MONITOR IS FROM YOUR EYES.

H. DISTANCE TO ACCOMMODATE THE WIDTH OF A WRISTPAD (5-10 CM.)

Figure 10.1. VDT Workstation and Operation Recommendations

VDT Station Checklist

Requirement	Comply Yes	No	NA
Has the station and terminal been adjusted to fit the operator?			
Does the screen have accessible brightness & contrast controls?			
Does the station have detachable keyboard?			
Can screen position be tilted?			
Does the distance from the table to the top of the space bar measure from 2 to 3 inches?			
Does the station have an adjustable chair (Chairs shall have adjustable heights & backrest tension & height adjustable to the lumbar (mid-back) region)?			
Is the chair adjusted so that the operator's arm is bent at an angle between 80 and 120 degrees?			
Does the station have an adjustable work table?			
Is the color of the display satisfactory with the operator?			
Is the station equipped with an adjustable stand for text work?			
If screen hoods or other devices are used, do they allow the operator to view the entire screen from a comfortable position?			
Is the illumination level at the station between 45fc and 65fc or 500 and 700 lux?			
If the station is located near a window, is the window equipped with a blind to reduce glare?			
Are characters on the screen clear and is the screen free of flicker or jitter?			

VDT Station Checklist

Requirement	Comply Yes	No	NA
Is the noise level of the surrounding area low enough not to cause excessive distraction?			
Are the operator's eyes tested before he/she started the job?			
Have the operator's eyes been checked at regular 5-year intervals or 3-year intervals if operator is over 45 years of age?			
Is the terminal situated or adjusted so that the display is lower than the operator's eyes?			
Is the angle formed by the line of contact between eye and display between 15 and 30 degrees from the horizontal with the top edge of the screen no higher than operator eye level?			
Is the contrast between light characters and dark background in the range of 3:1 and 15:1?			
Is the display screen of sufficient size to allow an adequate amount of information to be displayed?			
Is the work surface at least 35 inches wide?			
Is the screen from 16 to 19 inches from the operator's eyes with exceptions based on the individuals' needs?			
Is there adequate room under the work table to permit movement of operator's legs and a foot rest where necessary?			

VDT Station Checklist

Requirement	Comply Yes	No	NA
Is the operator given a break or other less tension involving work at least every 1 or 2 hours.			
Are direct lighting fixtures recessed or if fluorescent, are there baffles to cover them?			
Is the terminal equipped with any anti-glare devices?			
Is there adequate space so that a wrist pad may be placed in front of the keyboard? (wrist pads may require 2 to 4 inches between table edge and keyboard).			

11.0. SAFETY FEATURES IN ELECTRONIC EQUIPMENT

(See MIL-STD-2036, MIL-STD-454, the SPAWAR System Safety Checklist and individual equipment manuals for safety requirements and warnings.) The following safety features are incorporated in most military electronics and should not be modified without the specific authorization of the cognizant design authority.

11.1. Interlock Switches. Interlock switches may be of the following types:

a. Wired in series with the coil of a relay which de-energizes to open contacts in series with the power line leads to the electronic power supply unit.

b. Installed on the lid or door of the enclosure so as to break the circuit when the lid or door is opened.

c. Multiple interlock switches connected in series which may be used for increased safety.

d. Complex interlock systems which may be provided when several separate circuits must be opened for safety.

11.2. Uses of Bleeder Resistors. Bleeder resistors may be designed into the following:

a. Connected across the input terminals of high voltage dc power supplies.

b. Used to bleed dangerous charges off filter capacitors, since a high grade filter capacitor can maintain its charge for a long period of time.

11.3. Nonuse of Bleeder Resistors. Bleeder resistors should not be used if they are not designed into the system and especially as a temporary substitute when:

(1) The technician must discharge high voltage capacitors with a shorting bar before working on the high voltage circuit.

(2) Filter capacitors must be discharged as a matter of routine when repair work is to be done.

11.4. Current Limiting Resistors. Current limiting resistors should be used as follows:

a. Connected in series with the output lead of a high voltage power supply circuit to limit the current to a safe value when a short circuit or an accidental contact causing excessive loading occurs. This prevents equipment damage.

b. Extreme caution should be exercised at all times when working on live circuits as current limiting resistors will not limit currents to safe values if personal contact is made.

11.5. Insulated Controls. Insulated controls shall be used on all electronic equipment where practicable.

a. Metal knobs, dials, switches, and adjustment screws shall be used only in "cold chassis" equipment; they are not to be used with ac/dc powered devices. These items and metal control shafts shall be grounded where

practicable.

b. Rheostats and potentiometers in high voltage circuits must be placed far enough back of the panel to permit an insulated shaft coupling between the device and the control knob.

11.6. Power Line Safety. Power line safety measures should be followed:

a. Only approved line cords in good condition should be used.

b. Cords must be protected with insulating grommets at the point where they pass through the chassis or panel.

12.0. Hazardous Material

Some hazardous materials commonly encountered when maintaining electronic equipment are cleaning solvents, cryogenics, inert gases, toxic paints and toxic or nuisance dusts from drilling, and sanding or abrasive cleaning. Appropriate workplace design, procedures, respiratory protection, and personal protective equipment shall be provided to protect personnel. Consult Material Safety Data Sheets and product labelling for each individual material hazard. Details on hazardous materials control and management are provided in OPNAVINST 4110.2, SPAWARINST 4110.1 and local hazardous materials instructions. The following topics cover some of the hazards typically found in electronic equipment.

12.1. Cathode-Ray Tubes. Extreme caution must be exercised when handling a cathode-ray tube (CRT). The glass envelope encloses a high vacuum and, because of the large surface area, the envelope is subject to considerable force due to atmospheric pressure.

12.1.1. Personal Protection. To avoid serious injury, adequate precautions must be taken at all times to minimize the danger of breaking the envelope, resulting in a violent implosion of the glass envelope. Safety goggles, gloves, and protective clothing should be worn by personnel when handling a CRT.

12.1.2. Handling Procedures

a. Follow the tube manufacturer's instruction manual.

b. Keep the CRT tube in its carton until ready for use.

c. Do not strike or scratch the envelope or exert any pressure on the tube neck.

d. If it is necessary to set the tube down prior to installation, always set the face of the tube on a padded surface.

e. During installation, do not stand in front of the tube. In the event of an implosion, the electron gun and neck may be propelled at high velocity through the tube face. Phosphors in some tubes are extremely toxic. If contact is made notify the medical officer immediately.

12.1.3. Disposal. Return the sealed tube in its shipping carton to the manufacturer, or to the local Defense Reutilization and Marketing Office (DRMO) for disposal in accordance with local disposal regulations.

12.2. Batteries

12.2.1. General Rules for Battery Handling and Use. Storage batteries shall be changed and charged in accordance with 29 CFR1910.268 (b) (2), 1910.178(g) and 1910.305 (j)(7). The following apply to all battery uses and operations:

a. All battery circuits shall be provided with overcurrent protection.

b. Since battery explosion can result from a shorted battery, extreme caution shall be taken to prevent any inadvertent contact with the battery terminals.

c. Protective covers shall be provided to prevent contact with battery to prevent hazardous voltages and battery explosions.

d. Connections, polarity, minimum acceptable voltage, nominal voltage and type(s) of batteries required shall be marked in a prominent place and on battery compartments.

e. Before shipment or inactive storage of equipment containing batteries, the batteries shall be removed.

f. All battery compartments, rooms, and areas shall be well ventilated to prevent accumulation of explosive gas and buildup of heat. NO SMOKING signs shall be posted in the vicinity of batteries.

g. Be sure to ventilate a battery compartment which has been sealed before turning on lights, making or breaking electrical connections, or performing any type of work in the compartment.

h. Wear eye and face protection and gloves and aprons suitable for protection against chemical spillage when handling batteries.

i. Prior to making repairs or removing the battery, de-energize the equipment and disconnect the ground terminal first.

j. Turn off the battery switch when equipment is not in use.

k. Keep the temperature of the battery compartment below 95 degrees Fahrenheit, if possible.

l. Store batteries in a cool, adequately ventilated place having adequate fire protection.

m. Battery disposal shall be through the local public works or property disposal office.

12.2.2. Battery Charging. All personnel involved in battery charging shall be trained in the methods of preventing battery explosions and spilled electrolyte. Safety instructions shall be posted in the immediate vicinity of the charging operation. Battery charging shall be only allowed in specifically designated non-hazardous locations. Ensure that vent caps are open and protected from splashing electrolyte out into the surrounding area. The battery or compartment cover(s) shall be open to dissipate heat. Smoking shall be prohibited in the charging area. Tools and other metallic objects shall be kept away from the top of uncovered batteries.

a. De-energizing. The circuit shall be de-energized before making any repairs to terminal connections or before batteries are connected to or disconnected from the charging line.

b. Sparks and flames. Extreme care shall be exercised to avoid striking sparks and open flames in the vicinity of batteries while being charged. Even when optimum ventilation is provided, the hydrogen concentration immediately above the cells is within the explosive limits when charging at a fully gassing rate.

c. Ventilation. Charging shall not be started until it has been ascertained that the battery compartment or charging room is adequately ventilated. Charging shall be stopped whenever ventilation is interrupted and shall not be resumed until adequate ventilation has been restored. Battery charging facilities are considered to be adequately ventilated when the hydrogen concentration at distances greater than six inches above the cells is maintained below three percent. Charging facilities located in large open spaces having adequate industrial ventilation may not require supplementary

ventilation, or a localized airflow directed over the cells may suffice. Unless adequacy has been definitely determined, particularly for facilities located in confined spaces, a survey of the hydrogen concentration should be made with the equipment operating under freely gassing conditions. Portable hydrogen combustible gas indicators are available in standard stock (e.g., 6665-00-664-4650) for this purpose. In charging lead-acid batteries at a freely gassing rate, the flow of exhaust air in cubic feet per minute, Q, required to maintain a safe level (three percent) in a closed compartment containing N number of cells at a charging rate of I amperes may be computed from the formula:

$$Q = 0.018(I)(N)$$

This formula includes an air distribution safety factor of two which allows for nonuniform distribution of air flow over the cells and for extraneous currents not contributing to the required hydrogen dilution.

12.2.3. Handling Electrolytes

a. Protective Clothing. When engaged in electrolyte handling, mixing, or filling operations, personnel shall wear face shields and chemically resistant gloves, footwear, aprons or coveralls, and chemical goggles.

b. Mixing. Water shall never be poured directly into battery acid. The acid must always be poured slowly into the water.

c. Handling equipment. Large containers of electrolytes such as acid carboys shall not be handled manually but should be moved by appropriate material handling equipment. Permanent mixing and filling facilities shall be designed so as to minimize the hazards of manual handling and spillage. Provisions shall also be made for flushing and neutralizing spilled electrolyte, fire protection, protecting charging apparatus from moving vehicles, and adequate ventilation and dispersal of fumes from gassing batteries.

d. Showers and eye fountains. Deluge showers and eyewash fountains shall be provided in the immediate vicinity of all battery maintenance and electrolyte handling operations.

12.2.4. Lithium Batteries

12.2.4.1. Background. Manufacturers are aware that under certain conditions lithium anode cells may be unsafe. Some manufacturers have incorporated safety devices into the units such as pressure relief mechanisms, fuses to protect against overload, and diodes to prevent cell reversal. The battery manufacturer has no control over the end use of the battery and therefore there is no assurance that the safety devices incorporated in a battery are satisfactory for each use to which it is applied. Lithium batteries are being used in various applications and in some instances can be included in equipment being procured without the knowledge of the purchasing activity. Batteries using a lithium metal anode, coupled with either thionyl chloride, sulfur dioxide, or carbon monofluoride cathodes have been known to explode, causing serious injuries and even fatalities. These accidents prompted programs to regulate lithium batteries in equipment in the fleet.

12.2.4.2. General Requirements. Lithium batteries shall not be used without the express safety approval of COMNAVSEASYSCOM.(SEA 665, and for submarines shall also receive PMS 393T approval). Lithium cells shall not be used in applications where other power sources are practicable. All procurements of battery powered equipment shall specifically state that lithium batteries

shall not be used without the specific authorization of the procuring activity. Use and approval for use shall be per NAVSEA Technical Manual S9310-AQ-SAF010

12.2.4.3. Use. Whether fresh or discharged, lithium batteries shall not be pierced, crushed, burned, intentionally dropped, cannibalized, dismantled, modified, or otherwise carelessly handled, nor shall they be short-circuited, charged or used in any way other than their intended use.

12.2.4.4. Storage.

a. Lithium cells and batteries shall be stored in their original shipping containers in a cool, ventilated shelter.

b. The storage area shall be isolated from other hazards and combustible material and used only for the storage of unused lithium batteries.

c. Since the effect of mass storage on the hazard degree is not known, the quantity stored in an area shall be kept to the minimum consistent with requirements.

d. Batteries in storage shall be retained in unit packages, preferably shipping containers, to prevent heat transfer between batteries.

12.2.4.5. Disposal. Since most of the documented accidents have occurred with a partially or fully discharged lithium battery, batteries should be removed from equipment upon completion of useful life. The exposed terminal should be insulated to prevent short circuits, and the battery is to be turned into an appropriate disposal agency. When possible, agencies licensed to dispose of hazardous material should be utilized. If this is not possible then dispose of as follows:

a. At sea, discharge overboard in deep water (in excess of 500 feet) outside the prohibited zone (50 mile limit). Do not store for shore disposal.

b. Ashore, batteries should be buried in a controlled hazardous waste landfill. Disposal directions may be obtained from the local Public Works Center or the Navy Environmental Support Office, (NESO 20.2-011 Hazardous Waste Disposal Guide), and the DOD Disposal Manual DOD 4160.21M.

c. Used lithium batteries are not to be allowed to accumulate and disposal should be effected promptly. A collection point and storage area separate from other combustible material shall be established for batteries awaiting disposal. Lithium batteries are not to be disposed of or transported with normally generated refuse.

12.2.4.6. Lithium Fires. An extinguisher suitable for metal fires (Class D fires), e.g. MET-L-X or LITH-X, should be used to extinguish burning lithium. When such a dry powder type fire extinguisher is used, some of the extinguishing agent may spread throughout a wide area around the point of use. Therefore, if at all possible, remove items such as electronic instruments which could be contaminated by the powder particles (sodium chloride base with MET-L-X and graphite base with LITH-X) from any area where a dry powder type extinguisher might be used. This guidance is primarily for battery assembly facilities, since the design and size of currently contemplated lithium batteries for fleet use will preclude the occurrence of lithium metal fires.

12.2.4.7. Respirators. When entering a storage space in which lithium batteries have vented gases, supplied air respirators or self-contained

breathing apparatus approved by the National Institute for Occupational Safety and Health (NIOSH) shall be worn.

12.2.5. Mercury Batteries. Mercury in almost any form poses a health hazard, particularly when the vapors of mercury and unstable mercury compounds are inhaled, ingested, or come in direct contact with the skin. Because mercury is a health hazard, its use must be kept under strict control. All electronic equipment, associated test equipment, materials, finishes, circuit boards and other components should be free of mercury and unstable mercury compounds. Control of the habitable environment must include monitoring of mercury contamination caused by mercury spills and any unusual situations where contamination is suspected.

12.2.5.1. Requirements. Any contracts involving the procurement of equipment shall specify that no mercury or unstable mercury compounds will be used in the manufacture or test of equipment intended for use aboard surface ships, submarines, aircraft, enclosed areas at shore stations and other confined spaces unless specifically approved by the project agency or office. Exclusion of mercury and permission for mercury clauses are to be included in the contract documents. These clauses shall be quoted from NAVSEAINST 5100.3 series. Unless specifically approved by COMNAVSEASYSCOM, mercury batteries are not allowed aboard submarines. To minimize the possibility of having a mercury cell battery explode, the following precautions should be taken:

a. Never discharge a mercury cell battery after its voltage has fallen below 70 percent of its nominal voltage, or after it fails to operate the equipment in which it is used.

b. Never place a direct short circuit on a mercury cell battery.

c. Never leave the battery switch "on" when the equipment is not in use, or after the battery fails to operate the equipment.

d. Never retain exhausted mercury cell batteries. Discard them as soon as possible through the property disposal officer. The jacket of the batteries should not be purposely damaged prior to temporary storage or shore disposal.

e. Store the batteries in an adequately ventilated, preferably cool, fireproof area.

f. Do not incinerate.

12.2.6. Nickel Cadmium Batteries. Two of the more serious hazards from nickel cadmium batteries result from the configuration in which they are charged and the charging rate.

12.2.6.1. Charging In Series. Nickel cadmium batteries have exploded while being charged, resulting in injury to personnel. This was probably due to not using the proper precautions when charging the battery, rather than a defective battery. Nickel cadmium batteries or cells must be charged only in series, never in parallel. Cell imbalances cause different resistances which vary the charging rates of the cells when charged in parallel. This may cause a "thermal runaway."

12.2.6.2 Charging Rate. Higher than recommended charging rates or voltages may result in gas evolution of hydrogen and oxygen -- an explosive mixture which is easily ignited. The manual charging rate for a nickel cadmium battery is c/10, where "c" is the ampere-hour capacity of the battery. This is the recommended constant current charging rate at the ten hour rate. For example:

the charging rate for a 4.0 ampere-hour nickel cadmium battery or cell would be 0.4 amperes at a maximum voltage of 1.5 volts per cell. A completely discharged battery requires 14 to 16 hours of charging. With properly designed batteries, gassing due to overcharging is practically nil under these conditions. Constant voltage charging is not recommended.

12.2.6.3 Other Precautions. Nickel cadmium batteries should never be placed near other heat producing components. In high rate discharge applications the battery should be ventilated, because high current discharges result in high temperatures which may cause cell damage. Care should also be taken to prevent a short circuit. Battery shops for nickel cadmium batteries should have their own tools and service areas, separated from those for lead acid batteries, to reduce the possibility of contamination problems.

12.2.6.4 Summary. In summary, the following precautions are recommended:

a. Charge nickel cadmium batteries or cells in series only; never charge them in parallel.

b. Use the proper constant current charging rate of c/10 (or c/100 for trickle or float charge) at 1.5 volts per cell.

c. Maintain the battery temperature below 113 degrees Fahrenheit, if possible. Thermal runaway, especially from an improper charging unit, can cause battery explosion.

d. Avoid short circuits and situations where they are likely to arise inadvertently.

e. Have separate tools and a separate service area for nickel cadmium batteries.

12.3. Waveguide Gases

a. Waveguides may be pressurized with inert gases such as nitrogen, Freon, or sulfur hexafluoride. These gases when released into a confined space may displace the oxygen sufficiently to suffocate the occupants of the space. Additionally if an arc-over occurs in the waveguide, Freon or sulfur hexafluoride may decompose into highly toxic and corrosive gases such as phosgene and fluorine. Fluorine may cause extreme lung irritation and hemorrhaging.

b. Waveguides shall always be kept well sealed and adequate room ventilation shall be provided where leakage from the waveguide is possible. The room exhaust fan shall provide a complete change of air every several minutes to prevent concentration of toxic gases. Respiratory protective devices such as air supplied respirators are recommended for maintenance personnel working on pressurized waveguides employing sulfur hexafluoride, freon (trichlorotrifluoroethane) or nitrogen. The use of such respiratory devices shall be limited to emergency or intermittent exposure conditions and shall not be relied upon as the sole safety measure for controlling the personnel toxicity hazard.

12.4. Sonic Cleaners. Due to fire danger and toxicity, do not use solvents in sonic cleaners unless approved by an industrial hygienist and safety specialist. Use only detergents approved for the specific sonic cleaners. The use of detergent NSN 9Q-7930-00-085-6911 (5 gallon container) is recommended. Mix 20 ounces of detergent to 30 gallons of water at 140 degrees F. For heavy degreasing work, increase detergent to 30 ounces with 30 gallons of water.

12.5. Solvents and Cleaning Agents

12.5.1. Policy. The least hazardous cleaning agent that will accomplish the task shall be used in every circumstance, especially where the same agent is used repeatedly over a long period of time. Acid-based cleaning solutions may be the most hazardous, and their immediate effects the most obvious.

12.5.2. Methods

Soap with water is probably the least hazardous agent. The common practice is to use something in between these two extremes. For example, nonflammable, inert organic solvents often seem to be more effective than soap and water. The order of priority is as follows:

a. Detergents -- least toxic but may leave a residue or corrode electrical contacts.

b. Inert organic solvents:

1. Trichlorotrifluoroethane (Freon 113) -- CNO message 272020Z Sep 85 forbids use of Freon 113 unless no safer substitute can be found. It may be used safely in small quantities from a safety can or small spray can for spot cleaning in a well ventilated area. Open containers of Freon 113 may vaporize and cause suffocation by displacing breathable air or could cause heart arrhythmia. As little as one-half cup of Freon 113 if completely vaporized in a 27 cubic meter room will reach the hazardous threshold limit value (TLV) of 1000 parts per million (ppm).

If large quantities of Freon are required and safe substitutes cannot be found, an industrial hygienist must be consulted and special controls must be instituted. Typical controls may be to:

(a) Conduct operations outdoors.

(b) Provide forced air ventilation.

(c) Use air line respirator.

(d) Use approved safety containers for Freon and keep covered as much as possible.

(e) In case of spills of Freon, evacuate the area immediately and use forced air ventilation to purge the space. Obtain emergency services from the Hazardous Spill Coordinator, industrial hygienist, and the fire department rescue squad.

In accordance with SECNAVINST 5090.5 of 20 November 1989 and OPNAVINST 5090.2 of 22 January 1990 concerning the management of ozone depleting substances, purchase and use of Freon 113 are banned. However, existing stocks of Freon 113 may be used until they are depleted.

2. (1,1,1) Trichloroethane -- While this solvent is widely used as a contact cleaner and sold as a nonflammable "safety solvent," it has a much lower threshold limit value and is therefore more toxic than Freon 113. If used in an unventilated area it can cause unconsciousness and death or long term health effects. This solvent may be used in small quantities from safety cans or spray cans for spot cleaning in well ventilated areas. If more than small quantities are to be used, such as in cleaning vats, the operation shall be evaluated by an industrial hygienist. Typical controls and emergency spills cleanup would be the same as those instituted for the use of Freon.

3. Carbon Tetrachloride and Trichloroethylene -- Forbidden for general use in the Navy.

c. Acid Cleaning Solutions -- Phenol (carbolic acid), chromic acid, and other similar cleaning compounds shall only be used after it has been determined that no other cleaning compound is available to perform the same quality task. All uses of these compounds shall be evaluated by an industrial hygienist and appropriate safety, health, and environmental controls shall be initiated.

12.6. Gunk Tanks and Open Vats

a. Gunk tanks and open vats shall be covered at all times to prevent the escape of toxic and flammable vapors. These tanks shall be isolated from the general work area and shall be provided with adequate ventilation to ensure that the vapor concentrations are below the threshold limit values (TLV) of 29 CFR Part 1910.1000 in the event the tank cover is inadvertently left open. No smoking or open flame shall be permitted in the area. Tanks and vats shall have a sign affixed, "NO SMOKING OR OPEN FLAME PERMITTED IN THIS AREA".

b. Carbon tetrachloride, trichloroethylene, tetrachloroethane and perchloroethylene shall not be used.

c. Gunk tank and open vat operations shall be approved by an industrial hygienist and safety specialist prior to initial use.

12.7. Solvent Vapor Degreasers

12.7.1. Design.

a. Solvent vapor degreasers shall be designed, installed and operated in accordance with ASTM standard D3698 and ASTM STP 310A, Handbook of Vapor Degreasing as well as local safety and environmental regulations. Personnel exposure to solvent vapors shall not exceed the limits of 29 CFR Part 1910.1000. Each installation must be evaluated by an industrial hygieniest. No smoking, welding or other ultraviolet light sources or open flames shall be allowed. Warning signs shall be posted on all ventilation systems.

12.7.2. Training. At the time of initial assignment and annually thereafter for each degreaser operator, direct supervisor, and persons responsible for maintenance of degreasers, a training program shall be provided in solvent vapor degreasing operations including instruction on the specific hazards and effects of the solvent in use, the necessity of controlling exposure, emergency procedures, the procedures for safe operation and maintenance of degreasers, the contents of these work practices and appendices attached thereto, and the contents of the Handbook of Vapor Degreasing (ASTM STP 310).

12.7.3. Documentation

a. The instruction manual for the degreaser, the material safety data sheet for the solvent in use, and a copy of these work practices shall be maintained in a legible condition and retained in a solvent resistant container at the operating site of the degreaser by the operator and adequately identified.

b. For each new halogenated solvent a new training, education, and information program shall be implemented. Equipment modification as necessary shall be made and an appropriate change shall be made in the sign on the degreaser with respect to the chemical solvent in use.

12.7.4. Signs. All solvent degreasers shall have attached to them legible, highly durable sign or signs bearing at least the following information:

a. The word "DANGER"

b. The phrase "(Chemical Name of solvent in use) Vapor degreasing operations."

c. A warning sentence "Avoid inhalation of vapor and skin contact. High vapor concentrations can cause unconsciousness or death".

d. Other adequate warnings and first aid instruction.

12.7.5. Labels. Apply precautionary labels to the degreaser tank, all containers, storage tanks, drums, or equipment containing any of the solvents. The label shall include at least the following information:

a. The word "WARNING"

b. The chemical name and trade name of the solvent

c. Manufacturer's name and address

d. A warning sentence on the type of physical/health hazard and target organs as given on the manufacturer's label or Material Safety Data Sheet (MSDS), for example, "Use only in well ventilated area. Avoid inhalation of vapor and skin contact. High vapor concentrations can cause unconsciousness or death."

e. Other necessary warnings, precautions, personal protective equipment, and first aid instructions.

12.7.6. Personal Protective Equipment. Where there is a possibility of sprays or spills, or where there may be eye or repeated skin contact with solvents or corrosives, impermeable clothing, gloves, other coverings and eye and face protection, eye wash and shower facilities and first aid facilities shall be provided.

12.8. Polychlorinated Biphenyls (PCBs). PCBs are synthetic oils having excellent dielectric and low flammability properties. They have been used extensively as dielectric fluids in capacitors, transformers, and filters and in hydraulic fluids, heat transfer fluids, plasticizers, adhesives and dust control agents. PCBs released into the environment do not break down unless exposed to high temperatures. Instead, they bioaccumulate in the food chain, that is, they accumulate in the tissues of living organisms and as one organism feeds on another, progressively greater concentrations occur as the food chain progresses upward toward man. PCBs or their breakdown products may cause, among other things, reproductive failures, gastric disorders, skin lesions, and tumors in laboratory animals. Studies of workers exposed to PCBs have shown a number of adverse symptoms and effects including chloracne, digestive disturbances, jaundice, impotence, throat and respiratory irritations and severe headaches. Because of growing concern over these adverse effects, regulations were passed banning the manufacture and future use after 1 January 1977 under Title 40, Code of Federal Regulations, Part 761, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions. 40 CFR 761 further issued labeling requirements and disposal restrictions for PCBs and equipment containing PCBs. Monsanto Corporation sold PCBs under the trade name "Askarel." Companies who used PCBs in the manufacture of transformers and capacitors and for other uses often used other trade names.

12.8.1. Methods of Determining Hazardous Quantities. 40 CFR 761 allows capacitors and other electronic equipment with PCBs manufactured before 1977 to be used for their useful lives. Additionally, capacitors and filters containing less than three pounds of PCBs need not be disposed of in any special way. All capacitors having more than three pounds of PCBs must be labeled and disposed of as required by 40 CFR 761. PCB weight can be estimated using the following formulas:

a. Oil filled capacitors occupying the volume of approximately two bricks may be large enough to have more than three pounds of PCBs. A more precise estimate is given by:

PCB weight (in ounces) = Total volume of capacitor (in cubic inches) X 0.27 oz.

b. Filters contain both capacitors and coils. The following formula provides an estimate of the PCB weight in the filters:

PCB weight = Total weight X 0.30.

Capacitors for use at less than 2000 volts need not be labeled until taken out of service prior to disposal. Capacitors for use at more than 2000 volts must be labeled while still in service. Disposal must be accomplished as required in 40 CFR 761. Transformers in electronic equipment usually do not contain PCBs. External power transformers supplying the equipment may have PCBs. Their labeling and disposal is the responsibility of the Public Works Lead Activity (PWLA).

12.8.2. Requirements. If the quantity of PCBs in an equipment is greater than three pounds, ensure that all safety labeling and disposal requirements are met. When working with PCBs provide adequate ventilation and personal protective impermeable clothing such as gloves, aprons, and goggles. Should PCBs contact the skin, wash thoroughly. In the event of spill or fire, contact fire safety and medical officials. Post warning signs, and rope off necessary area.

If it is not certain whether equipment or bulk containers holding more than three pounds of oil manufactured before 1977 actually contain PCBs, provide the manufacturer's name, part number, and NSN (if possible) of each part to the Naval Energy and Environmental Support Activity, Port Hueneme, CA, for determination of PCB content. In the meantime, assume that the parts contain PCBs and handle them accordingly. Testing for PCBs can also be arranged for by contacting a local public works center or an industrial hygienist at a nearby Navy hospital.

12.9. Cadmium. Cadmium is widely used in electroplating, in some solders, and in NiCD/alkaline batteries. Cadmium-plated screws and equipment racks are commonly specified for use in corrosive atmospheres such as those encountered aboard ship. When vaporized through heating (such as welding) or burning (through incineration or accidental fires), cadmium can be the source of deadly vapors. In addition to the inhalation danger, there is the problem of the absorption of particles of cadmium through a body wound or cut. If it is absolutely necessary to weld cadmium-plated parts, self-contained breathing apparatus, or an air line, with a face mask shall be used by the welder and others who could breathe the vapors. Welding may be conducted only with the approval of the cognizant industrial hygienist.

12.10. Aerosol Cans. Some of the aerosols used in electronics include TV tuner cleaners and lubricants, insulating sprays, compressed air dusters, corrosion inhibitors, degreasers, circuit coolers, and magnetic tape head

cleaners. In addition, paints, lacquers, and a host of products from cleaning agents to emergency medical agents, and even food, come in aerosol cans.

12.10.1. Hazards. There are two distinct types of hazards from aerosol cans. First, the contents may be hazardous. Second, the package itself may be hazardous. It is normally not possible to directly inspect the contents of aerosol cans before using them. Therefore, the labels should be read and appropriate precautions taken, depending on the nature of the contents listed. Two other problems may arise with the contents. Because the materials are expelled as a fine spray of droplets or dust, they may be flammable under circumstances which one would not ordinarily expect. Also, toxic materials, which would ordinarily not be expected to be airborne, may be inhaled, ingested, irritate the eyes, or drift into areas where they are not wanted. The contents include both the material being sprayed and the propellant. The propellant may be highly flammable, even though the material being sprayed is not.

12.10.2. Precautions. Direct the spray away from the face, and use adequate ventilation. Never spray the contents of an aerosol can near any open flame or any other potential source of ignition. Smoking shall be prohibited when aerosol cans are in use. Keep aerosol cans away from any source of heat. Under sufficient heat they may explode with disastrous, possibly fatal, consequences. The contents may be totally inert and yet explode violently due to pressure buildup. On hot days don't leave them in a car or truck. Keep them away from direct sunlight, hot water pipes, soldering irons, soldering torches, and incinerators.

12.11. Cryogenic and Liquid Gases. Cryogenic and liquid gases commonly encountered include liquid nitrogen, oxygen, hydrogen, helium, methane liquified natural gas (LNG), propane, and butane. There are many others. All are materials which would be gases at room temperature and atmospheric pressure. Some gases require both high pressure and low temperature for liquification. Others require only low temperatures, while others such as propane and butane, can be liquified at room temperature under moderate or even very slight pressure. Butane is often used in disposable cigarette lighters.

12.11.1. Uses. Cryogenics are used in many ways. Certain electronic components require cooling to liquid nitrogen or even liquid helium temperatures for their proper operation. Such devices include superconducting quantum interference devices (SQUIDs) for the detection of weak magnetic fields and radio signals, photodetectors, parametric amplifiers and masers, as well as many others. Liquid nitrogen may also be used simply as an efficient coolant for devices operating at room temperature. Liquid oxygen and hydrogen provide an efficient method of storing fuel and oxydizer for fuel cells and rocket engines in space craft. Many industrial processes use cryogenics. LNG, propane, and butane are widely used as fuels.

12.11.2. Hazards. Cryogenic systems are unforgiving of mistreatment. If cryogenic liquids are released in large quantities, the consequences can be severe, or even catastrophic. They usually have temperatures between -100 degrees and -150 degrees, substantially below the temperature of any material they may contact. Their release results in immediate flash vaporization, rapid boiling, and the production of copious quantities of vapor. The immediate consequence of a spill or leak can range from local chilling to a violent explosion. An explosion may occur even with totally inert gases due to flash vaporization in a closed chamber. Many materials, even the high carbon steel in supports for tanks, undergo drastic changes in their properties when supercooled. They may become brittle and break or otherwise fail, compounding the catastrophe. If the cryogenic liquids are flammable, a

further blast and fire may ensue. The principle hazard of the noncryogenic liquid gases like propane and butane is their extreme volatility and potential for fire and blast. Even if no blast or fire occurs, the hazards to personnel can be great. The hazards include low temperatures, frostbite, toxicity, and air displacement. Flash vaporization in an enclosed area can lead to suffocation even if the gases are not toxic and no cryogenic liquids actually touch the involved personnel.

12.11.3. Requirements. Only properly trained personnel with approved personal protective equipment shall handle liquid gases or cryogenic materials.

12.12. Coolants

12.12.1. Ethylene Glycol. Silver plated wire or tin lead solder coated wires impressed with a dc potential can react chemically with glycol solutions to produce flammable gases and ignition of these gases. To avoid this problem when the glycol and water solution cannot be replaced with a more suitable coolant, a 60/40 glycol and water solution with cathodic type corrosion inhibitors plus a silver chelating agent should be used in the following concentration:

Sodium mercaptobenzothiazole (NaMBT) 1% by weight
Benzotriazole (BZT) 0.5% by weight

This particular mixture has been tested and found effective in precluding the ignition reactions on both silver and tin lead up to 24 vdc. Any other mixture should be tested to verify effectiveness. Wires that are terminated on connectors by soldering and impressed with a 100 volt potential (ac or dc) must be protected with a dielectric potting compound to reduce the hazards of glycol and water-induced fires. At this potential there is no single cure-all to eliminate ignition hazards.

12.12.2. Compressed Gases. Compressed gases, such as CO_2 and nitrogen are sometimes used as coolants. These gases can displace air and cause suffocation. Adequate ventilation shall always be provided when these gases are used.

12.12.3. Standards. The Compressed Gas Association standards, OSHA standards, and specific material safety data sheets will provide guidance concerning hazards associated with the handling and use of compressed gases.

12.13. Beryllium. Beryllium dust, either as a metal or as an oxide, is highly toxic. It can cause beryllicosis of the lungs and dermatitis. Beryllium oxide (beryllia), a white ceramic material identical in appearance to aluminum oxide (alumina), is widely used in electronic equipment, because it has the very desirable properties of being both an electrical insulator and a good conductor of heat. Mounting pads for power transistors and other electronic components that generate heat are often made of beryllia. It is often used for the fins and other heat dissipative elements of high power microwave tubes and for the insulators of high power transmitting antennas. Beryllium, the metal, is also a good conductor of heat, very light, and strong. It is less likely to be encountered in ordinary electronic equipment, but has been used for antennas in missile nose cones and similar specialized circumstances. It is also used as an alloy in springs and clips.

12.13.1. Hazard Description. In practice only the dust of beryllium and its oxide are hazardous. Solid blocks of these materials are not a significant hazard. Extreme precautions must be taken only when machining, drilling and grinding these solid pieces, or otherwise working with thin wafers which can

break and cause dust. Before grinding, machining or cutting white ceramic insulators, determine whether the material is beryllia.

12.13.2. Safety Procedures. If it is absolutely necessary to undertake welding, drilling, cutting, grinding, grit blasting or acid cleaning of materials containing beryllium or beryllia, the operations shall be done only by individuals with the proper training and after review of the operation by an industrial hygienist to ensure proper controls and personnel protective equipment are in place to protect respiratory system, skin, and eyes. Cleanup of beryllium or beryllia dust shall be by wet methods or industrial vacuum cleaners with high efficiency particulate air (HEPA) filters to eliminate the possibility of making the dust airborne. Broken parts should be disassembled under water. Skin and eyes should be thoroughly washed after exposure to these substances. Disposal shall be done only by hazardous waste disposal office.

12.13.3. Labeling. All contracts for equipment or material that may contain beryllium shall require that each beryllium containing part be marked with a warning, "beryllium/beryllium compound, do not machine, drill, grind, acid clean or weld."

12.14. List of Some Typical Hazardous Materials or Items Containing Hazardous Materials in Electronics Operations. Below are listed some of the possible hazardous materials or components encountered in electronics operations for which there should be material safety data sheets, labelling and safety procedures. See FED-STD-313C for a more complete listing.

a. Aerosols

b. Asbestos

c. Batteries, such as Lithium, Mercury, and Lead Acid Batteries

d. Battery Electrolytes

e. Beryllium and beryllium compounds

f. Cadmium

g. Cathode-ray Tubes

h. Cleaning Agents

i. Coolants Such as Freon

j. Cryogenic Materials

k. Degreasers

l. Duplicating Fluids

m. Fiberglass

n. Gunk Tanks

o. Mercury

p. Moca and Other Potting Compounds

q. Paints

r. Polychlorinated Biphenyls (PCBs)

s. Radioactive Materials

t. Radioluminescent Materials

u. Solvents and Cleaning Agents

v. Sonic Cleaners

w. Toxic, Flammable, Corrosive, Radioactive, Oxidizing Materials and Compressed Gases

x. Waveguide Pressurizing Gases

13.0. SHIPS

The basic document for safety aboard ship is OPNAVINST 5100.19B. Electronics Safety is further addressed in NAVSEA 0967-LP-000-0100 (Electronics Installation and Maintenance Book). Electrical safety aboard ship is also contained in NAVSEA S9086-KC-STM-000/CH-300 R1 (NAVSEA Technical Manual (NSTM) Chapter 300), "Electric Plant, General," . This document lists other chapters of the NSTM which pertain to specific electrical equipment and operations aboard ship. Following are some additional safety practices.

13.1. Precautions during Ship Overhaul and Repair. Local safety officials of a shipyard or facility will normally notify the commanding officer when electronic safety measures are required. Ship's transmitting equipment shall be secured when:

a. Overhead cranes are operating in the close proximity of the transmitting antennas.

b. Personnel are placing or removing rigging or structures aloft.

c. Flammable, combustible or explosive material is being loaded or off-loaded on the adjacent dock or on other ships or barges in the near vicinity.

13.2. Energizing When Ship is in Dry Dock. The electronic equipment of a ship may be energized only with the express permission of the docking officer. The hull must be adequately grounded. Excitation is not to be applied to sonar transducers unless they are properly immersed. Sonar hoist mechanisms are to be operated only after it has been definitely ascertained that adequate clearance exists for the moving elements within their full limit of travel and that no mechanical damage will be incurred by such operation. This determination is to be made as soon as practicable after the dock is emptied.

If sufficient clearance does not exist, positive steps shall be taken to prevent lowering of the transducer by gravity, manual, or power operation. See OPNAVINST 5100.19B.

13.3. Working Aloft Procedures. When working aloft, comply with the requirements of OPNAVINST 3120.32 series and OPNAVINST 5100.19B. The following flowchart may assist in conforming to these requirements.

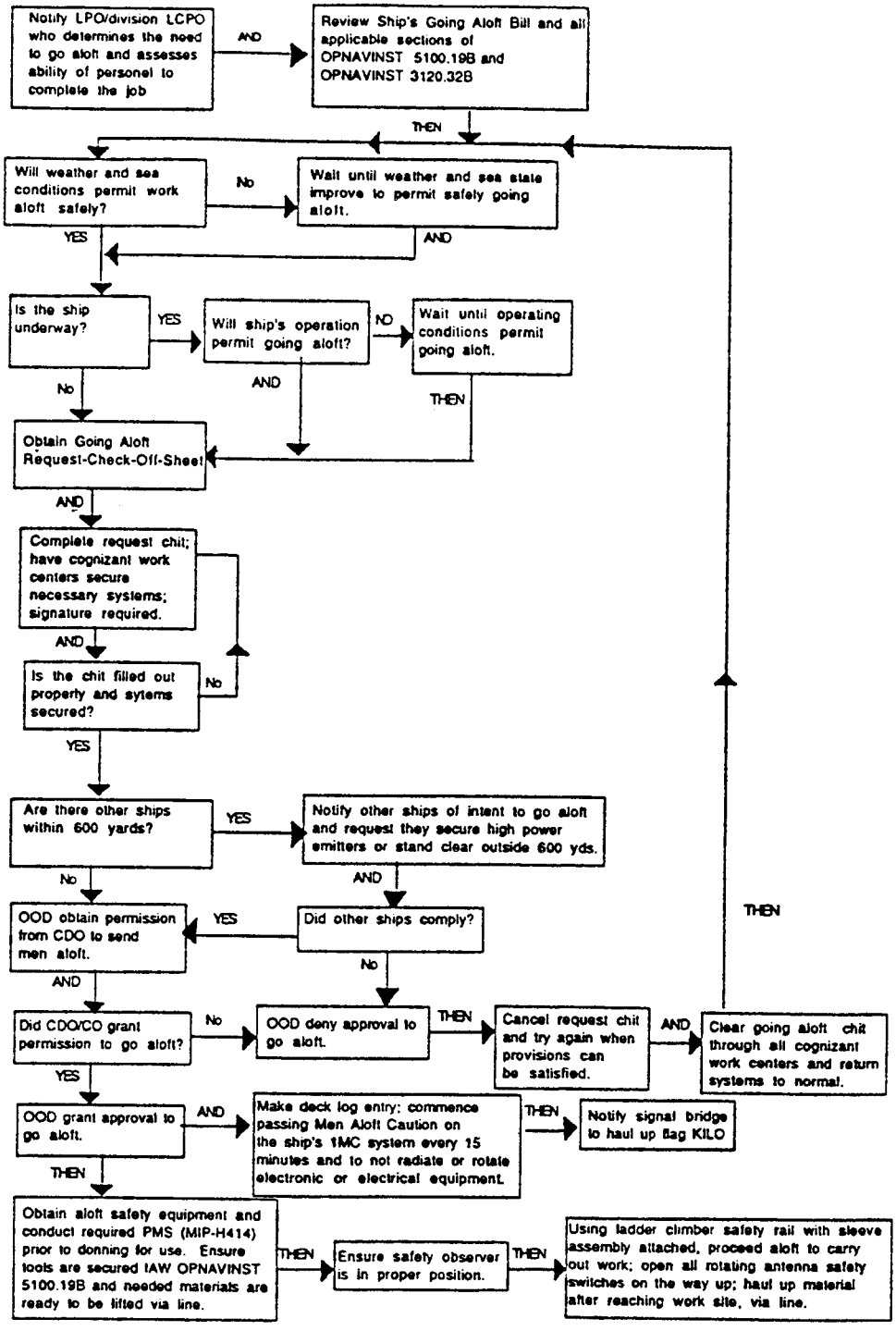


Figure 13.3-1

FLOW DIAGRAM OF ACTIONS REQUIRED BEFORE GOING ALOFT

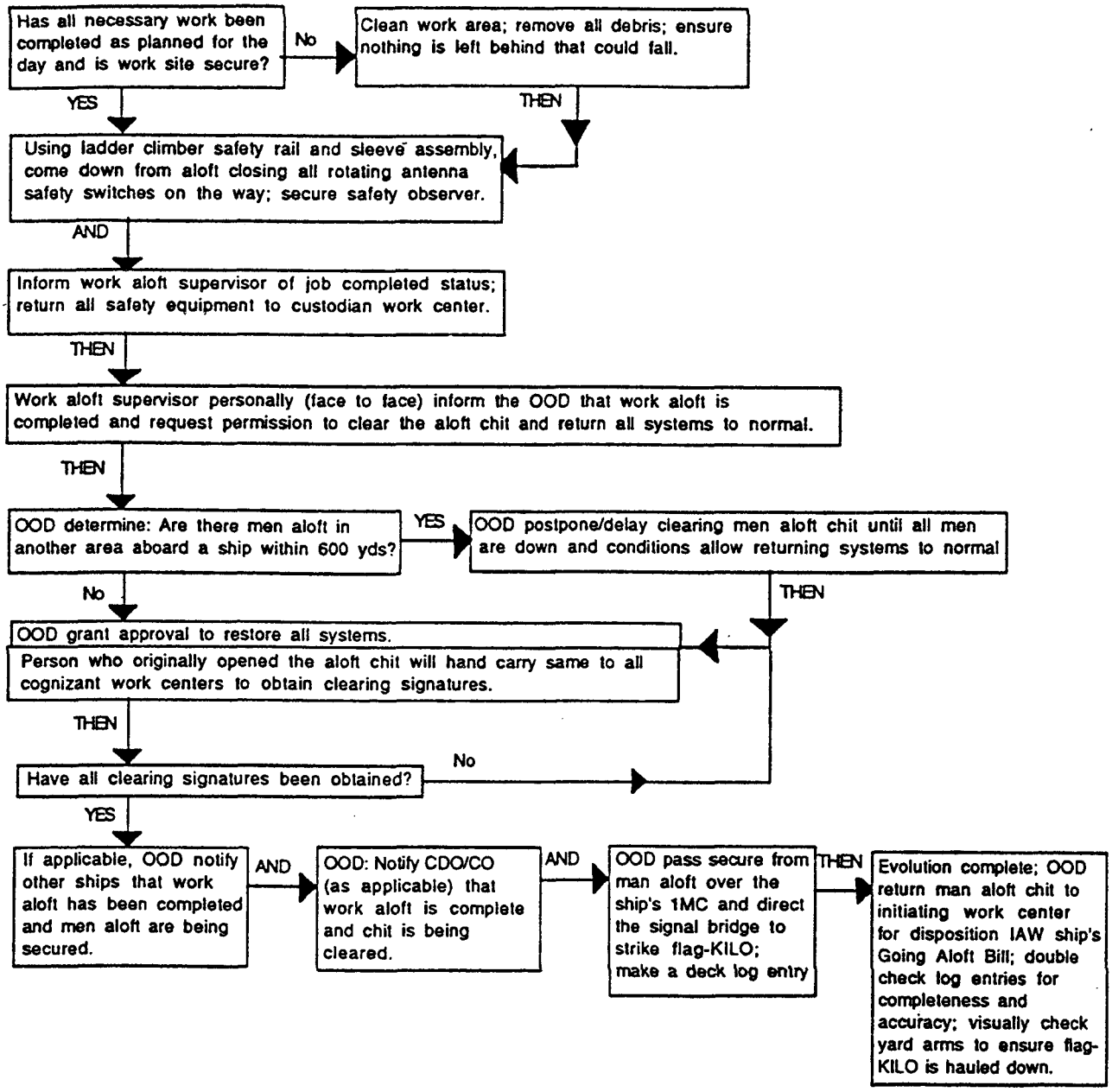


Figure 13.3-2 FLOW DIAGRAM OF ACTIONS REQUIRED AFTER WORK ALOFT IS COMPLETED